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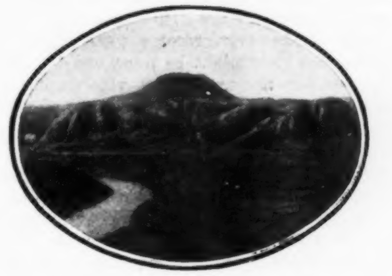
PANORAMA OF THE GREAT ZIKKURAT, SHOWING TO THE LEFT THE BARRACKS, TEMPLE OF ASSUR, HITTITE PERIPTEROS AND STOA, AND TO THE RIGHT THE EASTERN PLATEAU.

BASALT CORNERSTONE OF SALMANASSAR II. IN SITU.

DOLORITE STELE AND SCULPTURED HITTITE GOD.

CLAY POMMEL OR KNOB OF SALMANASSAR II.

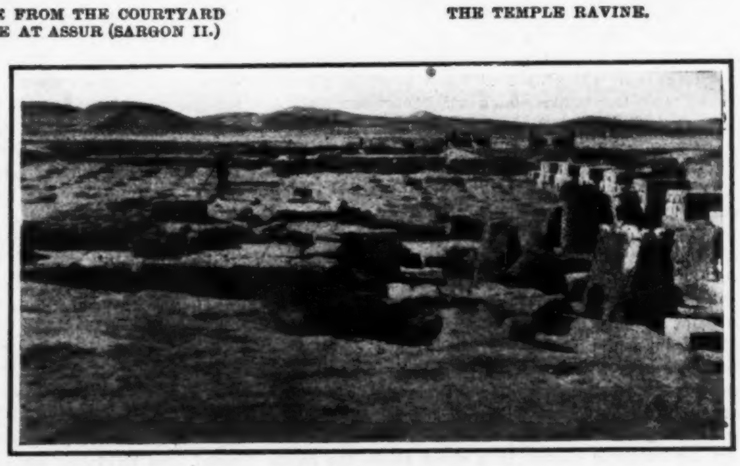


ZIKKURAT FROM THE NORTH.

PAVEMENT TILE FROM THE COURTYARD OF THE TEMPLE AT ASSUR (SARGON II.)

THE TEMPLE RAVINE.

NORTH FRONT OF THE MOUND OF ASSUR.



THE NEW YEAR'S FESTIVAL HOUSE SEEN FROM THE EAST.

RECENT EXCAVATIONS IN ASSUR AND BABYLON.—[SEE PAGE 328.]

LIGHTNING ARRESTERS.*

SOME RECENT DEVELOPMENTS.

BY DAVID B. RUSHMORE, M. AM. INST. E. E.

THE necessity for lightning protection arises from the consideration of the loss which might ensue from damage by lightning to buildings and other structures. Aside from the danger to ordinary buildings and structures, there exists in the case of certain electrical structures, such as pole lines and electric generating and transformer stations, a peculiar susceptibility to damage by lightning inherent in the physical form of the structure. The damage that might result from lightning can be ultimately referred to interruption of service and to damage of apparatus of value. In consideration of these facts, lightning protection is essential up to the point where it ceases to effect a saving. Beyond this point, for example where the cost of lightning protection is greater than any probable loss, the protection ceases to be economical.

There are, however, certain cases where for special reasons absolute protection is requisite at any cost, as for example, in a powder mill or gas-producing station. Ordinarily, a lightning discharge, which is an equalization of potential between the earth and either clouds or saturated atmosphere above the earth, will take place through the path of least resistance, but as pointed out by Rowland, there is a certain factor, somewhat resembling inertia, which causes the lightning once started to follow sometimes an irregular path, similarly, for instance, as when a piece of paper is suddenly torn. Transmission lines and buildings of ordinary height surrounded by trees are not peculiarly subject to damage from lightning because they cover a comparatively small portion of earth and are surrounded by objects of greater height, which offer a better path for the lightning discharge to the earth. They do, however, receive some discharge, and the damage which might be done can be very great. It is therefore necessary to provide ample protection.

Generally speaking, the severe manifestations of lightning are confined to a relatively small area, which rarely exceeds in extent an area of one mile square. It may be concluded from this that protection apparatus situated at certain points along the line will afford no protection to remote points.

The fundamental consideration in the protection of structures from lightning is that the lightning, like any other electrical discharge, will follow the path of least resistance. It is necessary, therefore, to supply a path of low resistance for the lightning discharge to follow to earth. In the case of a building with steel in its structure, a path is offered the lightning discharge through the steel frame to the earth, and as the earth resistance of the steel framework will necessarily be extremely low, any applied lightning conductor will meet a considerable rival in the steel framework. This holds, in a great measure, for gas and water piping as well. It therefore becomes necessary in the design of lightning conductors that the earth resistance be not only made as low as possible, but that the conductors be placed as far away from the rival path as is practicable; also, the resistance of the conductor must be as low as it is possible to make it under the existing circumstances.

Lightning may be divided into external and internal, the former being caused by atmospheric conditions and the latter by generated power in the line.

The effects of external lightning result from various causes, viz., direct strokes, electro-magnetic secondary strokes, and electro-static secondary strokes.

In a direct stroke, the point of discharge is suddenly raised to an enormously high potential so that the charge will probably find some path to ground through any insulation which might be applied. A wave will travel along the wire in both directions from the point of highest potential. This wave will be lower as it recedes and will be finally lost.

The more concentrated and higher the peak, the greater will be the frequency and consequently the shorter line distance it can travel before becoming insignificant. It follows, therefore, that a direct stroke will arc to ground near the point of stroke, and that protection at remoter points will not affect the point in question.

Electro-magnetic secondary strokes are caused by discharges near the line which cause, by induction, a condition in the line analogous to that of direct stroke. This condition becomes severe only when the discharge is parallel to the line or nearly so.

An electro-static charge in a cloud above the earth is accompanied by a corresponding opposite charge on the earth. The line gradually assumes the potential of the latter through static leakage. If, now, a discharge takes place, the ground charge is at once neutralized, but the line is left at a high potential and is in a measure in the same condition as in the case of a direct stroke. The peak of the resulting potential, however, is not so high, and the frequency therefore lower. The wave train will therefore travel farther and may eventually enter the station. At the station the wave may pass to ground through the lightning conductors or may be reflected by the inductance of the apparatus, in which case it may pile up to as much as twice its original height, when something arcs over, generally the transformer bushing.

As already explained, an air accumulated charge above the earth will be accompanied by a corresponding charge directly below it upon the earth, and this latter charge will be communicated to the line by leakage.

When the inducing charges move away, the line charge must leak or the potential difference between the line and the earth may become sufficient to puncture the insulators. The leakage path must be supplied for a line not connected to ground by grounded neutral. A static charge in a line is easily handled by means of proper protecting apparatus.

Among the causes of internal lightning are interrupted arc, arcing ground, poor synchronizing, connecting in of dead transformers and lines, sudden changes of load, etc.

A certain fundamental frequency of vibration dependent upon the inductance and capacity is inherent in every line, but it might also vibrate at any harmonic of the fundamental, or combination of harmonics. The low frequency oscillations usually contain the most power and are therefore the most dangerous and difficult to handle. High frequency oscillations are dangerous locally, but do not travel far.

Generally speaking, the broad requirements for lightning protection consist in supplying paths to ground for any charge which might accumulate on lines or machinery from any cause whatever. The ideal arrester will cause excessive potential differences to be relieved instantaneously and stop the flow of current, as soon as the potential has fallen to safe limits for the line. No one type of lightning arrester fulfills all requirements, and accordingly it is found expedient to use different types of combinations in different situations and under different conditions.

To protect the buildings, such as powder mills, etc., where absolute protection is imperative, a number of gas pipes of about 1½ inches to 2 inches outside diameter are driven 6 to 8 feet into the ground, and about 6 feet distant from each other, so surrounding the building with a fence of ground connections. From each of the gas pipes rises a lightning conductor. Such conductors should have at least 5 inches or 6 inches periphery: that is, a ribbon or flat strip 2½ inches to 3 inches wide is used. The material and thickness are of little consequence and iron can be used, except where prohibited owing to danger of corrosion.

These lightning conductors rise from the gas pipes, upward, sloping first toward the building under an angle against the vertical of 20 deg. to 30 deg. and then running straight up at about 6 inches to 8 inches (or even 12 inches) from the building. At the edge of the roof, the lightning conductors curve without sharp bends or kinks, but with a long radius curve, and run across the roof, under an inclination against the horizontal of preferably not less than 30 deg. and gather in the lightning rod which projects vertically, about 6 to 8 feet. From the lightning rod, the conductors radiate somewhat like the wires of a parrot cage. When the building is large, more than one rod may be used and the bases are connected by a horizontal lightning conductor. Sharp bends and kinks should everywhere be avoided. All the lightning conductors are joined together by a horizontal conductor just above or below the ground.

The plane of the flat ribbon should be parallel to the surface of the building along which it passes. Where the surface of the building is sheathed with iron or other conductor, metal supports fastened thereto should be used for supporting the lightning conductors, but where the walls are of non-conducting material, the lightning conductors should be supported by non-conducting brackets.

The greatest possible care should be taken to have no insulated metal work in the building, such being extremely dangerous in producing, by induction, sparks or brush discharges. All metal contained in the building should be connected at its highest and lowest points by lightning conductors of at least half the size of those covering the building, to the next adjacent lightning conductor, and the connection from the top of the metal should slope upward, while that from the bottom of the metal should slope downward toward the lightning conductor.

Plain gas pipes without salt are recommended for ground connections. Salt greatly reduces the ground resistance, but this already is amply low with many pipes in parallel, and salt exerts an injurious effect upon trees and plants. Many pipes in parallel are necessary to give low impedance to prevent the formation of an electro-static field.

For the protection of electric circuits, grounded guard wires are best, and when the cost over the whole system would prove prohibitive, they should be confined to such localities as are peculiarly liable to suffer destructive discharges. Three ground wires are required for the best practicable protection. One of these should be placed on top and in the middle of the line, and should be a heavy galvanized steel cable, and the other two, which should be heavy telegraph wires, are placed outside and above the top side conductors. The ground wires should be earthed at every pole for the first ten or twelve poles from the building and at every second pole on the rest of the line.

Graded resistance or aluminium type lightning arresters should be installed on every feeder issuing from the station, and on primary and secondary of every transformer, and a surge protector in the station, but choke coils, having a large number of turns, should not be used in the station, as they represent a possible source of danger.

Lightning may consist of a single discharge of great violence and very small duration or it may consist of a great number of distinct discharges following each other rapidly and each lasting only a very short time. Thus the same path may serve for a great number of short discharges closely following each other.

The total time of passage and number of discharges have been determined by Mr. Alex. Larson from photographic records made with revolving camera. In an extreme case 48 flashes were recorded in a total interval of 0.624 second.

Where from internal causes, e. g., flashing over a bushing or insulator, the arcing ground sends a series of oscillations through the circuit, it is necessary to provide an arrester which will continue to discharge the abnormal voltage for a sufficient period to permit the operator to locate and isolate the trouble. Half an hour is generally found to suffice for the period of an arrester as this will give time to discover the point of trouble, where this is remote from the station.

Horn arresters placed along the line at various places will do much to protect insulators from puncturing or arcing across. These horn arresters should be adjusted to arc at something below the wet arc-over voltage of the insulators and should be connected to earth direct. Only one phase per pole should be protected by a horn arrester so that in the event of two horns arcing simultaneously, the earth resistance can be utilized to limit the discharge. Ground wires should not be grounded at poles carrying horn arresters. Lightning rods above wooden poles are advantageous.

Graded resistance multigap or aluminium arresters should be used on outgoing and incoming lines. Choke coils should be in the circuit just back of arresters, which, in turn, are placed quite near the passages and are provided with disconnecting switches.

Single-phase locomotives have a specially designed graded resistance multigap type of arrester which meets the requirements of space limitation.

For voltages exceeding 60,000 the aluminium or electrolytic types of arrester should be recommended exclusively, and even for moderate and low voltages they are so far superior to other types, that their ultimate selection reverts to a question only of initial cost.

Aluminium cell arresters are designed especially to take care of recurrent or continuous discharges, which are, as a rule, of comparatively low frequency and therefore travel over the entire system, so that even if the system is supplied with multigap arresters, it is advisable to install one or more aluminium cell arresters having low adjustment. This arrangement will prevent the other types of arresters from discharging continuously until they are injured.

The general theory of the multigap arrester is as

* From a paper presented at meeting of Central Electric Railway Association, Indianapolis.

follows: When the voltage is applied across a series of multigap cylinders, the voltage distribution is not uniform. The voltage distributes according to the capacity of the cylinders, both between themselves and also to ground, and the capacity of the cylinders to ground results in the concentration of voltage across the gaps nearest the line. When the voltage across the end gaps reaches a certain value, they arc across, passing the strain back to the other gaps, which in turn arc over until the spark has passed entirely across. The arrester in this manner arcs over at a voltage much lower than would be required if the voltage distributed evenly. When the arrester has arced over and current is flowing, the voltage then does distribute evenly between the gaps and is for this reason too low to maintain an alternating current arc. The arc therefore lasts only to the end of the half cycle and then goes out. The maximum voltage per gap at which the arc will extinguish at the end of the half cycle depends to a great extent upon the metal of the cylinders. Thus, some metals are more efficient than others in extinguishing the arc.

When the voltage of an alternating current arc passes through zero of course no current flows. Before the current flows in the reverse direction, the voltage must again break through the dielectric; the voltage required to do this depends upon how much the dielectric has been weakened by the passage of the arc. The cooler the arc, the less is the dielectric weakened and the higher will be the voltage required to reverse the arc. As the temperature of the arc depends upon the boiling point of the cathode metal, in very much the same way as the temperature of steam depends upon the boiling point of the water, metals with low boiling point are used for the lightning arrester cylinders in order to keep down the arc temperature.

The use of resistance in a lightning arrester needs very careful consideration. Lightning does not readily pass through resistance, especially when in series with multigaps, and, therefore, series resistance should not be used. At the same time it is very desirable in some way to limit the line current. This problem has at last been solved by use of low shunt resistance, shunting a part of the gaps, and so proportioned as to divert the arc from the gaps after the discharge has crossed to ground. Shunt resistance has been used before, but never for this purpose, but was never made low enough to divert the arc in this way.

It is obvious, of course, that a discharge taking place through a high resistance will not relieve the line except in the case of the static. What happens, however, is something like this: When a surge of dangerous voltage rises, and before it reaches a danger point, the series gaps are over. The series gaps then being practically short-circuited by the arc, the voltage concentrates across the lowest division of the shunted gaps, and these at once also break down. The current is then limited by the medium resistance, and the voltage is concentrated across the second division of the arrester. If these gaps break down, the discharge is limited only by the low resistance, which should take care of most cases. If necessary, however, the voltage can "break back" in this way and cut out all resistance. The number of gaps to rectify depends largely upon the current that can flow. In this arrester the number of gaps discharging increases as the limiting resistance decreases. The arrester will therefore operate and extinguish the arc at the end of a half cycle, no matter which path the current takes.

The aluminium cell lightning arrester consists essentially of a series of concentric inverted cones placed one above the other with a vertical spacing of about 0.3 inch. The cones are insulated from each other except for the electrolyte, which partially fills them. Each cell then consists of two aluminium cones and the intervening electrolyte. A sufficient number of cells placed in series form a complete arrester, the electrical characteristics of which are the same as of a single cell. The cones, complete with the electrolyte, are immersed in a tank of oil, which affords the necessary insulation and great heat-absorbing capacity.

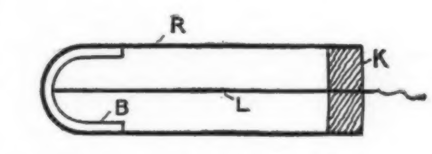
The efficiency of the cones as a lightning arrester depends upon a thin film which is formed upon the surface of the aluminium by a special process of manufacture. This film may be compared with the safety valve of a steam boiler, which opens at a definite pressure and allows the steam to escape. Each cell, two adjacent cones with intervening electrolyte, is designed to operate normally at 300 volts. If the potential rises to any value greater than 300 volts and less than 420 volts, the film allows the discharge to take place, but a thicker film is immediately formed, and the current is again decreased to a small value. When the line potential becomes normal its extra thickness of film gradually dissolves, leaving the film in its normal condition. At 420 volts (about 40 per cent above normal voltage) the film opens and allows a free and heavy discharge to take place. This voltage represents the maximum critical film value per cell. The plate area of the cells is sufficient to allow a discharge of more than 1,000 amperes at double normal potential, or 600 volts per cell. This represents a quantity of electricity many times greater than that usually liberated by an ordinary induced lightning stroke. Consequently, it is not possible to get an excessive potential across the terminals by such discharges.

The aluminium cell arrester is designed to be connected to the line through the adjustable horn-gaps. These gaps may be set so that the voltage will break across at any desired rise above the normal operating voltage. When the conditions warrant, the gaps can be set so as to allow the arrester to discharge when the line voltage rises only about 25 per cent. The horn-gaps perform three important functions; first, they act as spark-gaps, as explained; second, they may be used as disconnecting switches; and third, for subjecting the arrester to normal voltage. It is recommended that current be sent through the arrester every day or two, so as to assure proper formation of the film on the aluminium cones. The horn-gaps are so constructed that they can be easily short-circuited momentarily for accomplishing their purposes.

DIRECT REACTION OF THE HUMAN EAR TO ALTERNATING CURRENTS.

J. RIEDER, in Prometheus, reports on some observations which he has made, and which seem to show that under suitable conditions the tympanum of the ear is sensitive to electric alternations, so that we have, as it were, a special sense for certain electric conditions, and can become directly cognizant of the same. We quote in outline the author's own words:

In the telephone we observe indirectly the alternations of an electric current, by first converting them into vibrations of a membrane or disk, which latter then transmits the sound to the ear in the usual way. In the course of some experiments I have observed that the human ear can also react directly to alternating electric currents. The extremely simple apparatus required is shown in the accompanying diagram. *R* is a small test tube, with a metal coating *B* extending about one-fourth of the length of the tube.



From this coating a metal rod *L* passes outward through the cork *K*, which is fastened down with sealing wax. In fact, the tube forms a small Leyden jar without any outer coating.

If now the rod *L* is connected with one pole of a small induction coil, and the tube is held with its silvered end near the ear (taking care not to touch the connecting wire), a loud noise is heard on touching the second pole of the induction coil with the free hand. The same effect is produced without touching the second pole, if the latter is earthed. This occurs even if the observer is insulated from the ground by a pair of rubber shoes, although the sound is then diminished in intensity.

The cause of this phenomenon seems to be rather simple to explain. The human body, and with it the ear-drum, is charged by the successive current pulses, while the coating of the tube receives a charge of opposite sign. Thus the ear-drum is set vibrating, and we have the sensation of sound.

The sensibility of the ear was not very great, using this simple apparatus. The currents in a telephone could not be thus detected. But it must be remembered that the distance of the metal coating from the tympanum was very considerable, and perhaps better results could be obtained by means of a specially constructed small tube inserted into the ear. It seems possible that in this way sounds might be made audible to deaf people.

These experiments leave a certain after-effect upon the observer, a sense of pressure in the ear, showing that the ear is affected in a manner quite different from that involved in listening to an ordinary telephone. This seems to be a warning that a certain amount of caution will have to be exercised in conducting such experiments.

The sound can also be observed with an ordinary telephone, if the two wires are connected to one terminal of an induction coil, the other terminal of which is touched by the observer. This seems to indicate that disturbing noises which often occur in the telephone may not always be due to vibrations of the disk; they may be due directly to high-potential atmospheric electricity, without the intervention of the electromagnet. In some experiments made with a frictional machine, a sharp sound was heard at the passage of each spark. It seems quite out of the question that the disk of the telephone was in this case acted upon by the electromagnet.

These observations may perhaps have a practical application. If the author's view is correct, that charges upon the telephone line, due to atmospheric conditions, may act on the ear, not through the medium of the telephone disk, but directly, then it will probably be possible, by suitable construction, to eliminate the disturbing "accidental" noises, which often render conversation over the telephone unintelligible at the approach of a thunder storm.

THE EFFECTS OF WIRELESS TELEGRAPHY ON OPERATORS.

IT has been remarked that each step taken in the onward march of any applied science seems to bring into notice some fresh special pathological condition. Various previously unknown diseases dogged the steps of the earlier engineers, electricians, chemists, and balloonists. The dangers lurking in the Crookes tube —beneficent though it be when used under proper control—have been of late made tragically prominent. Among the numerous persons who are now learning to fly possibly some new pathological curiosity will before long come to be recognized. According to M. P. Bellile, a French naval surgeon on board the "Descartes," which has been engaged in the campaign in Morocco, the members of the ship's company who were employed in wireless telegraph duty developed various affections in consequence of the action of the Hertzian waves. Most commonly the telegraphists complained of their eyes, a slight conjunctivitis similar to that occurring among those who work with arc lamps being found. Although this of itself was not generally at all serious, yet in one case where the attacks recurred again and again, ceratitis was produced which resulted in a leucoma of the right cornea and consequent impairment of vision. In order to protect the eyes from damage by the ultra-violet rays of the electric emanation, which have a very powerful action, it was recommended that yellow or orange glasses should be worn. Not only were the eyes of the operators affected, but two cases of eczema—one of the wrist and one of the eyelid, both very difficult to cure—were seen, probably due to the same cause. Lastly, one of the officials who had been employed for several years in wireless telegraphy suffered from painful palpitation of the heart which came on after working for any length of time at the instruments for sending messages. This man was quite free from any organic lesion of the heart. M. Bellile is disposed to think that a good many of the cases of "nervousness" and neurasthenia which seem now to be getting rather common among naval men may be due to the work which is being done in wireless telegraphy.—Lancet.

THE SCIENCE OF MANAGING BOILERS AND FURNACES.

EXPERIMENTS have shown a difference of 29 per cent in the quantity of fuel used by different stokers in generating equal quantities of steam with the same furnace, boiler, coal, and water, and in the same conditions. As combustion is a chemical process the cause of inefficiency in stoking, and its remedy, must be sought by chemical investigation. The principal product of combustion is carbon dioxide (CO_2), which is produced in perfect combustion. The production of this gas should be gaged continuously by one of the new automatic carbon dioxide meters. If the combustion is imperfect, carbon monoxide (CO) is produced also. The relative proportions of the two gases should be frequently determined by chemical analysis.

This is an important point, for one pound of coal produces 14,600 British thermal units when oxidized to carbon dioxide, but only 4,450 units when oxidized to carbon monoxide. The temperature of the products of combustion is also of importance, even when a heat economizer or regenerator is employed. It is always advantageous to utilize directly in the boiler as much heat as possible and to regulate the admission of air so as to reduce the temperature in the chimney to the lowest point compatible with good draft, for insufficient admission of air leads to the formation of carbon monoxide.

The importance of controlling the temperature and the proportion of carbon dioxide in the chimney gas is shown eloquently by the following results of experiment:

Per Cent of Carbon Dioxide.	Temperature Deg. F.	Per Cent of Fuel Wasted.
5	500	35.
5	400	28.
7	500	25.5
7	400	20.
10	500	18.
10	400	14.5
12	500	15.5
12	400	12.5
14	500	13.5
14	400	10.5

THE FIRST AMERICAN STEAM TURBINE.*

A DESCRIPTION OF THE "BAILEY JACK."

BY F. E. DRAKE.

EXAMINATION of the records of the United States Patent Office shows that early in the history of the country some of the possibilities of the use of steam as a motive power were recognized to a great extent, and men from many walks in life were engaged in designing machines intended to transmit the power of steam into motion that could be made to do useful work.

The first steam patent in this country bore the date of August 26th, 1791, and was issued to James Rumsay, "for improvement of Savary's steam engine." On the same date a patent was issued to John Fitch, "for propelling boats by steam"; one to Nathan Reed, "for an improved steam boiler"; three to John Stevens—later inventor of the screw propeller—two of which were for improvements in boilers and engines and one for "apparatus of steam to work bellows." On the same day, E. Cruse received a patent for an improvement to a steam boiler.

John Bailey's name is 39 on the list of United States patents, and ninth in the list of patents for apparatus involving the use of steam.

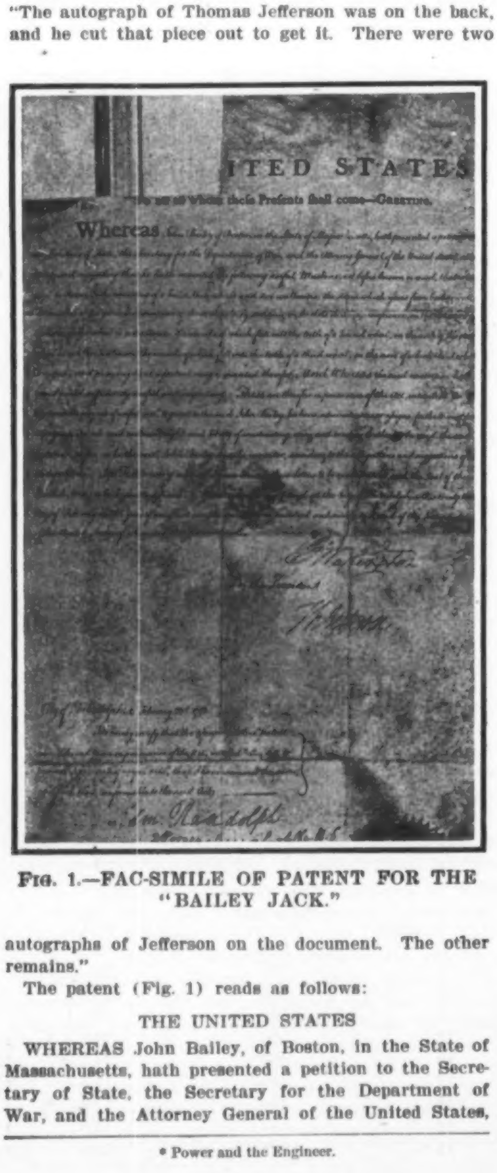
Seven of these patents issued to the persons here named dealt with the great problem of steam navigation; one only with the application of steam to a minor mechanical device, namely, John Stevens's steam bellows.

This shows that John Bailey's "jack" was the second article operated by steam, aside from a steam engine, for which a patent was issued in this country.

The patent and the original cast-iron machine for which it was issued are owned by Mr. Bailey's granddaughter, Miss Catherine Bailey, of Chancery Court, Lynn, Mass. Miss Bailey shows the original patent with great pride. It is on sheepskin parchment. The writing, in a clear hand, is still legible. The signature of Washington is faded.

A rectangular piece has been cut out of the upper left-hand corner of the parchment.

"An autograph collector did that," said Miss Bailey. "The autograph of Thomas Jefferson was on the back, and he cut that piece out to get it. There were two


ITED STATES

To all to whom these Presents shall come—Greeting.

Whereas

FIG. 1.—FAC-SIMILE OF PATENT FOR THE "BAILEY JACK."

autographs of Jefferson on the document. The other remains."

The patent (Fig. 1) reads as follows:

THE UNITED STATES

WHEREAS John Bailey, of Boston, in the State of Massachusetts, hath presented a petition to the Secretary of State, the Secretary for the Department of War, and the Attorney General of the United States, alledging and suggesting that he hath invented the following useful machine, not before known or used, that is to say, a Steam Jack, consisting of a boiler, three wheels and two wallowers; the steam which issues from boiling water in the said boiler gives

FIG. 2.—THE "BAILEY JACK."

motion to one of those wheels, by striking on buckets in its circumference; on the outer end of the axle of this wheel is a wallower, the rounds of which fall into the teeth of a second wheel; on the axle of this second wheel is another wallower, the rounds of which fall into teeth of a third wheel; on the axle of which third wheel is a spit; and praying that a patent may be granted therefor; AND WHEREAS the said invention hath been deemed sufficiently useful and important: These are therefore in pursuance of the act, entitled "An act to promote the progress of useful arts," to grant to the said John Bailey, his

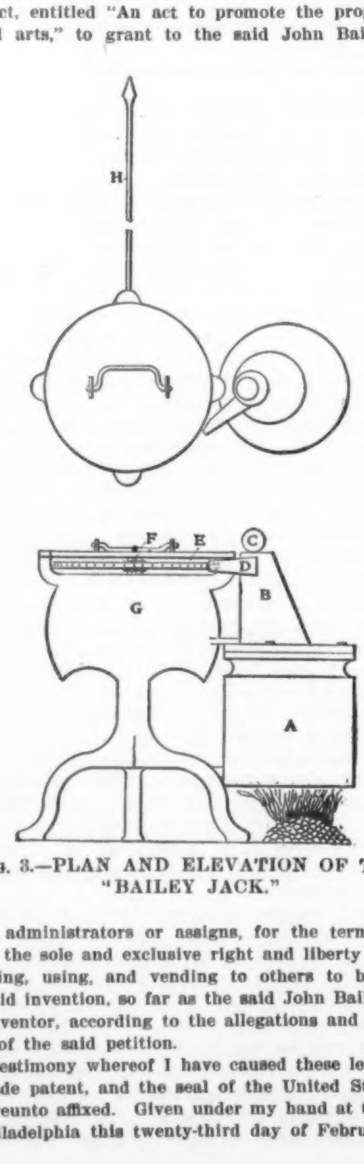


FIG. 3.—PLAN AND ELEVATION OF THE "BAILEY JACK."

heirs, administrators or assigns, for the term of 14 years, the sole and exclusive right and liberty of constructing, using, and vending to others to be used, the said invention, so far as the said John Bailey was the inventor, according to the allegations and suggestions of the said petition.

In testimony whereof I have caused these letters to be made patent, and the seal of the United States to be hereunto affixed. Given under my hand at the city of Philadelphia this twenty-third day of February, in the year of our Lord one thousand seven hundred and ninety-two; and of the Independence of the United States of America the sixteenth.

GEO. WASHINGTON.

By the President. THOMAS JEFFERSON.

City of Philadelphia, February 23d, 1792—I do hereby certify that the foregoing letters Patent were delivered to me in pursuance of an act, entitled "An act to promote the progress of useful arts," that I have examined the same, and find them conformable to the said act.

EDMUND RANDOLPH,
Attorney General of the United States.

THE "BAILEY JACK."

In 1792, Mr. Bailey took out a patent on the "Bailey turbine," or as he called it, the "Bailey jack." The "Bailey jack" is a boiler and turbine combined and was invented for roasting fowls in the large open fireplaces they had in his time. The apparatus stands about 14 inches high and is of solid construction, weighing in all about twenty-five pounds. The boiler, the casing for the gears, and the plate above the bucket wheel are made of cast iron and are supported by three cast-iron legs which form part of the gear casing. The boiler is riveted to this casing.

The bucket wheel is about $7\frac{1}{2}$ inches in diameter and $\frac{1}{4}$ inch thick, made of wrought-iron plate. The buckets are ratchet teeth cut into the wheel, as shown in Figs. 2 and 3.

Through the center of the bucket wheel is a steel shaft about $\frac{1}{4}$ inch in diameter. The shaft has needle-point bearings, both top and bottom, very much like the pivot wheel of a watch. On the lower part of the shaft and inclosed in the casing is a system of worm gearing, or, as designated in the patent, "wheels and wallowers." These gears operate the arm or spit upon which birds were strung to be roasted. This arm made a revolution every two minutes. The bearings of the shaft are so fine and the entire mechanism is so accurately made and nicely balanced that even to-day (116 years from the date of the making) the turbine will revolve for several minutes when set in motion by a slight tap of the finger.

On the top of the boiler is a round ball which answers the double purpose of a safety valve and stopper for the hole through which the boiler is filled.

In Fig. 3 are shown the boiler *A*, the steam space *B*, the safety valve *C*, the nozzle *D*, the bucket wheel *E*, the shaft *F*, the gear casing *G*, and the spit *H*. Fig. 4 shows in detail the buckets and nozzle.

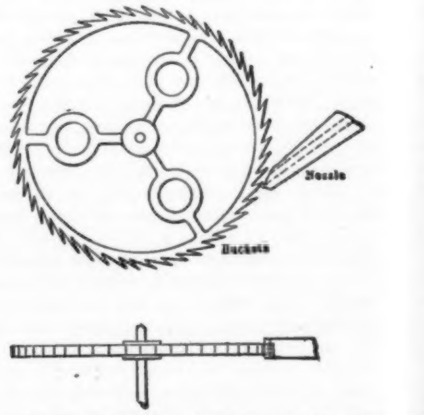


FIG. 4.—THE BUCKET WHEEL AND NOZZLE.

The turbine and letter of patent, Miss Bailey says, are to go to the Massachusetts Historical Society when she is through with them.

It is much to be regretted that the present owner of the jack would upon no consideration allow the opening up of the interior gears of the machine to show the "wheels and wallowers," as an examination would have revealed the manner of speed reduction and possibly a method of constructing worm gearing long before the days of the milling machine.

Magic Napkins (Serviettes Magiques).—Under this designation, fabrics are sold, by means of which metal objects can be rapidly polished. These fabrics consist of a woolen stuff, saturated with soap and tripoli and colored with a little coralline. They are made by dissolving 4 parts of Marseilles soap in 20 parts of water, adding 2 parts of tripoli to the solution, which is used to saturate a strip of cloth about 27 inches long and 4 inches wide, which is then allowed to dry.

* Power and the Engineer.

TIME AND LABOR SAVERS.

LITTLE THINGS FOR THE SHOP.

POSSIBLY the following information relative to small repair work on automobiles, other vehicles, or machinery may be of interest to some of our readers. Many of the points, of course, are already known, but it is expected that some, at least, will be new.

A washer of a specific thickness is often wanted, for instance, to take up a small amount of backlash or end-play in a shaft. In a case of this kind, use a washer thicker than required, and carefully file it

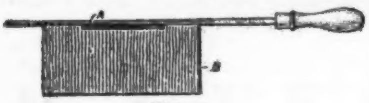


FIG. 1.

down. To do this sounds easy; but, handled in the ordinary way, is difficult to deal with. If one tries to grip it in the vise by the edge, it either springs out or rocks about in an annoying manner, and, in any case, it is impossible to file a washer thin and flat in this manner.

The operation is made easy if the washer is first passed between the jaws of the vise into the surface of a piece of soft wood endwise of the grain, as shown at Fig. 1, *A* being the washer and *B* the wood. In filing, the wood and metal are cut away together, and if one can handle the file at all well the washer can be removed from its bed as true and as thin as may be desired. For enlarging the center hole, if necessary, as large a round file as can be got through should be used, and with a little care a hole can be made that will be as true as if drilled. For making very thin washers use sheet phosphor-bronze, which can be obtained from 1/64 inch down to the thinness of tissue paper. Using a pair of spring dividers, one can strike out any size washer in a minute or two.

A useful material to have about the repair shop is a few feet of the thin soft iron strip, from ¾ inch to 1¼ inches wide, which is used on the edge of packing cases. It can be fashioned into excellent clips by the aid of the pliers and a round metal bar of suitable

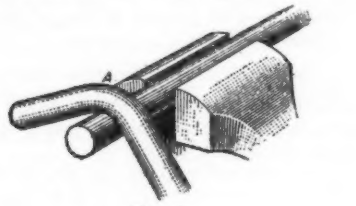


FIG. 2.

size on which to bend it. Among the box of spare nuts and bolts there should always be a dozen or so 3/16 round-headed bolts of various lengths, with square nuts, and then one need never be at a loss for a clip.

A usual repair-shop operation is making a sharp bend in a copper pipe. If a new carbureter is being fitted to a gasoline engine the novice usually makes the bend all right, but stops the pipe up at the same time. To make a really good bend requires care and experience; for anything over 5/16 inch diameter the pipe would have to be temporarily filled with lead. Good bends can be made by heating the pipe at the desired place, at *A*, Fig. 2, in a Bunsen flame till red hot, and cooling in water, and then bending a little at a time round a bar held in the vise, as shown. The amount of constriction at the bend is very slight, especially after touching up with a ball-pein hammer.

A small taper pin is often required for some part of the engine. The usual way to make it is to file it up from a piece of steel rod in the vise. Unless skillfully done, a lop-sided, ill-fitting pin is the result. A better

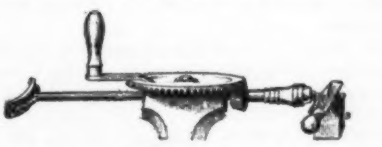


FIG. 3.

plan is to grip the hand drill, which every complete tool outfit should contain, firmly in the vise, fix a piece of steel rod of suitable diameter in the chuck, arrange a notched piece of wood, at *B*, Fig. 3, under the steel rod, and file it down with the right hand while one turns the drill-handle with the left. By this means as well-fitting a pin can be made as if turned upon a $300 lathe.

Some blacksmiths have experienced difficulty with a tight-fitting bolt or screw, and it is rare that one is provided with suitable stocks and dies to ease the threads. But by patient use of a "V" or knife-edge file worked slowly along the thread, turning the latter round meanwhile, it can always be eased down to a working fit, as shown at Fig. 4, in the case of an automobile sparking plug. The right kind of file, however, must be used—a half-round file will spoil the thread. This method is also useful for touching up a burred thread, so often the result of gripping a bolt or threaded part in the vise without any protection over the jaws, the fine steel teeth of which, being dead hard, will crush anything softer.

Clamps over the vise-jaws should invariably be used when any finished work has to be gripped. A pair can be made in a few minutes from a piece of soft sheet copper, although for some work sheet-lead clamps give a better grip. A good hold of a circular bar cannot be obtained by simply gripping direct between the jaws, as the pressure is practically only along a line, and, moreover, it is risky with a tube, as this is likely to be crushed. A pair of wood grips can easily be cut from two oblong pieces of hardwood, two semi-circular

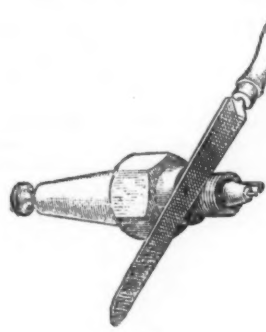


FIG. 4.

channels being made large enough to grip the largest circular piece likely to be used. Smaller diameter work can always be lapped round with paper to make it fit. Handled in this way, a bar or tube need not have a scratch left on its surface after leaving the vise.

In drilling holes, there are a few points to observe. Fluted drills are the best, as twist drills are liable to grip in the work and often break, especially in drilling through a piece of thin metal. A drill should be really sharp; blunt drills cause extraordinary exertion for little result, whereas a sharp one requires only a moderate pressure to work. Brass, gun metal, and cast iron are best drilled dry, and wrought iron and steel with a little thin oil on the drill point. Some kinds of cast iron are exceedingly hard on the surface, and the drill at first will hardly make any impression. Making a deep center-punch mark will generally facilitate matters. When a large hole, say, from ⅝ inch to ¾ inch diameter, has to be made, it is better to drill a

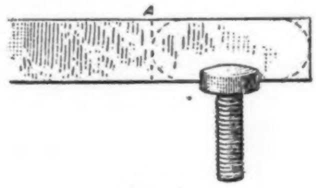


FIG. 5.

small hole first, really a pilot hole, to guide the larger drill; otherwise there is great risk of the large drill running all to one side of the spot desired. Hard steel, of course, cannot be touched with an ordinary drill; the metal must first be softened by leaving in the fire till just an even red heat is reached, and then burying in sand till it cools. Rehardening is not so easy, as some parts split or twist easily when plunged at a red heat into cold water. Caution must be used in the operation. Quenching in oil is safer; but the part cannot be made so hard.

The metal saw is a very handy tool; but the hardened steel blades are exceedingly brittle, and any twist or crookedness in the sawing operation causes a breakage. The fine-toothed blades should be used for iron and steel, and the coarser ones for brass and soft metals. For cutting through a brass or steel tube, use a fine-toothed blade, as the teeth rip off from the coarse ones. Before sawing, make a true circumferential line round the tube where the cut is desired; then, by turning the tube round a little between each cut, the latter will be nice and straight. The broken blades are useful at times for small repairs, as they are readily softened.

Spiral springs are so readily obtained in a large variety now that it is not often one is at a loss for one. The occasion may arise, however, and it is worth keeping in mind that the hand drill fixed in the vise, as shown in Fig. 3, makes a first-rate winder for spiral springs, using a piece of round steel rod as a mandrel. Steel spring wire of various gages can usually be obtained at hardware dealers.

FIG. 6.

There are occasions where time would be saved if it were not necessary every time to find a screwdriver of a certain size to unfasten a small screw. In automobile repairs, for illustration, take the cover of the carbureter float chamber, or the cover of the contact make-and-break, lubricator fitments, or any part fastened with a few small screws. It is a very simple matter to convert an ordinary screw into a thumbscrew, and it will be found well worth while to spend a little time in effecting the change. Obtain a narrow strip of hard-rolled sheet brass (or strip iron) a shade thicker than the slot in the screw, and ½ inch to ¾ inch wide. Trim the edge with a file, that is, one end of the strip, so that it may be knocked tightly and squarely in the slot of the screw, as shown in Fig. 5. Now, hold the screw, supported on the strip, in the Bunsen flame for a few moments, and touch the edge near the slot with a stick of zinc. The solder will run in and around the joint, making all strong and secure. Cut off with a cold chisel at *A*, or nick across with a file, and trim the corners with a file, Fig. 6. Hexagon-head screws may be done in exactly the same manner if a slot is first carefully cut across the center of the head with the metal saw.

Making good connections to the end of wire cables is a bugbear at times. A very good one may be hammered out of soft copper tube, as shown in Fig. 7, the sketch being self-explanatory. The cable is stripped

FIG. 7.

and pushed into a short piece of copper tube of suitable size, which is first pinched in the vise jaws, thus effecting a good grip of the bared wire strands. Then, holding the copper piece on an anvil or iron block in the vise, spread it out with the hammer, drill the hole to suit, and saw or file through, finally trimming up the face and edges. Such a connection is practically everlasting, and easily detachable without having to take the terminal head off.

In straightening a spindle, light shaft, or valve stem, that has become accidentally bent, hammering the piece straight is crude and unmechanical, and generally results in bruising the piece. A better way is shown at Fig. 8. For this it is necessary to have a really good and strong parallel vise, as the straightening operation may easily cause a cheap cast-iron vise to snap across. Cut or file V notches in three hexagon nuts, lay the bent piece in the vise jaws as shown, with the nuts as supports and fulcrum. Apply steady pressure with the vise screw, and the piece will

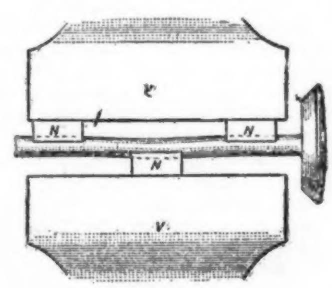


FIG. 8.

straighten out. The vise, with its strong, square thread and handle, makes an exceedingly powerful compound lever. Up to ¾ inch diameter, steel can be trued up if the piece be heated red and the blocks quickly manipulated in position. In actual practice it is not probable that an exhaust valve would become so much bent as that shown in the sketch, so that no

more than a very moderate pressure applied at the right point would be necessary to bring it true again. A practised hand would know almost by a glance along the stem and twisting the valve in the fingers whether it were true or not. It is better for the unpractised hand to test the piece by laying an ordinary steel straight-edge along it, and noting whether it agrees with it.

Those who intend to do automobile repair work often require metal brackets and angle pieces of a certain size and shape. These are quite easy to make with ordinary tools and vise out of soft-rolled brass or iron strip from 1/16 inch to ¼ inch thick, and this strip is so easy to obtain in a variety of widths from any metal warehouse that it does not pay, except in an emergency, to cut up a sheet. If brass is used, it had better be made quite soft by heating to redness and plunging into water. To save time and avoid waste of material, always make a thin cardboard pattern of the fitting required and work to it. In most cases the holes for screws may, with advantage, be drilled before bending the strip in the vise.

Copper wire is a material no automobile repair blacksmith can afford to be without, in view of the numerous temporary repairs that can be effected with it. The right sort of wire should be obtained; that is, it must be the soft ductile kind, and not the hard-drawn variety, which so easily twists off and is very difficult to manipulate. A variety of thicknesses, from No. 12 to 18 gage, is most useful; but one should never be without a good length of the special tinned copper wire, No. 22 gage, as used by electricians. It is surprising what repairs can be made with it by the exercise of a little ingenuity on broken gasoline and oil pipes, and many ignition parts. A gasoline pipe, which has a bad split in it, may be permanently repaired by cleaning the surface of the pipe with emery cloth, and wind closely over the damaged part a layer of the tinned wire and soldering it up. The tinned surface makes the soldering perfect and easy. It is useful material also for plugging up or covering over a hole in a radiator, gasoline tank, or lamp reservoir, to make a good soldered repair.

It is often the case that gasoline engine valves become short in the stem from the constant hammering, and if not of the adjustable type the proper opening of the valves cannot be obtained. There are several ways of adding a piece of steel to the stem; but, with the ordinary tools to hand, as good a method as any is to carefully drill a small hole from 3/32 inch to ⅛ inch diameter up to the stem, then file a steel pin that can be driven in very tight. Drill and countersink a hole through a piece of steel strip, and rivet on to the stem by the projecting bit of steel pin. Finally trim up with a file. Another way is to drill and tap a small hole up the stem, and screw a small steel bolt in.—Blacksmith and Wheelwright.

AEROPLANE PROBLEMS.

DIFFICULTIES IN CONSTRUCTION.

BY HERBERT CHATLEY, B.SC.

IT is needless to point out, however simple the root principles underlying the design of any machine may be, when the machine is to be built, extremely complex combinations of principles appear, so that the practical man is saddled with far more burdensome troubles than those which hamper the theorist.

A study of the various machines in existence has led the author to notice the following difficult problems:

(1) The determination of the relation between the area and weight.

(2) The adoption of a prime mover and propeller suited to the required speed and manipulative efficiency.

(3) The arrangement of the weight and supporting surfaces to give permanent stability and dirigibility.

(4) The selection of accessory appliances.

There are certain other points to be considered in a free development of the subject, but there will be enough to do in tackling these.

AREA AND WEIGHT.

If we presuppose that the machine is of the type having plane or nearly plane supporting surfaces and a positive angle, it may be said that the long series of experiments from Vinci to Langley has conclusively shown that the lift depends on the area, the square of the relative velocity and (approximately) the sine of the angle. These three quantities may be varied so as to give a lift slightly exceeding the weight, but the range through which they may be varied is not unlimited. Thus there is a minimum value of the velocity (corresponding to an angle of about 25 deg.), and the angle may not be decreased much below 2 deg. nor increased above 30 deg. without impairing the mechanical efficiency. Similarly the area cannot be greatly increased without increasing the weight.

On the face of it, the determination of the area would seem to be somewhat difficult, since a weight driven by large power at a large angle needs (comparatively) small area, and the same weight driven by small power at a small angle needs (comparatively) large area, the starting velocity being the same in each case.

A Dutch naturalist, Harting, discovered an approximate law for the relation between the area of a bird's wing and its weight, which seems peculiarly applicable, and the author has reduced it to English units (slightly increasing the constant) as follows:

Area (square feet) = 6 (weight in pounds)$^{2/3}$.

This works out very nearly to all cases of natural flight, and leads in the case of machines, such as are now experimented with (weight, say 1,000 pounds) to a ratio of area to weight = 2/3, i. e., each square foot lifts 1½ pounds. Some machines use larger areas, and, in consequence, need much more power; but, on the other hand, the starting velocity may be much lower.

This would indicate (as is indeed already well known) that the heavier the machine, the smaller may be the supporting surface. Thus, if the weight is 1,728 pounds, the area in square feet is half the weight in pounds, and if 2,397 pounds, the area in square feet is one-third the weight in pounds.

This question may well be concluded by a comparison of the areas of some machines with the above law:

Name.	Weight	Ratio of Weight to Area.	Ratio of Weight by Law.
Maxim	7,000	2.3	3.18
Santos Dumont, 14 Bis.	460	0.53	1.286
Farman	1,200	1.79	1.78

The last is a remarkable coincidence. The two previous machines, if the law is true, have an excess of area which may perhaps account for the difficulties experienced in controlling them.

It should be noticed that by adoption of this law, other factors being the same, the necessary soaring velocity varies as the sixth root of the weight.

MOTOR AND PROPELLER.

At the present time considerable difficulty is experienced in choosing a motor for an aeroplane. Two very light types, the Levavasseur "Antoinette" and Messrs. Dufaux Frères gasoline motors, have been evolved, but are subject at present to certain defects by reason of their exceedingly small weight. The experiments that have been made up to the present show that one effective horse-power will lift about 100 pounds at a speed of 30 miles per hour. Since, however, the combined efficiencies of gearing and propeller rarely exceed 50 per cent, this only means 50 pounds per B. H. P. Making a fourth allowance for traveling at a somewhat lower speed a lift of about 30 pounds per B. H. P. can be relied on, so that a rough notion of the B. H. P. necessary can be obtained by the following rule:

$$\frac{\text{Weight of machine without motor}}{35} = \text{B. H. P. needed.}$$

This allows 5 pounds per horse-power for the weight of the motor. The Dufaux motor, which holds the record for lightness, consists (in the 120-horse-power set) of ten cylinders, directly paired and double acting, overhung shaft, water-cooled cylinders, and air-cooled piston. The Esnault-Pelterie motor should also be mentioned in this connection, since its weight is nearly as low as the other two types, and it seems very fairly efficient.

In almost all the later machines the flywheel is dispensed with, uniformity of torque being maintained by balancing the pistons carefully. The kinetic energy stored in the propeller is also relied on to some extent.

As to the propeller itself, there is considerable diversity of opinion, but in nearly all cases it has been found preferable to use fan-bladed propellers with two, three, or four blades. The two-bladed type gives seemingly the best results, owing to the arrangement giving a minimum disturbance of the air. The author does not propose to give any formulæ in relation to the propeller since the final rule of thumb methods used by the French school of aviators were given by Capt. Forbes* at a meeting of the Junior Institution of Engineers in February, 1908. He would, however, mention certain points worthy in his opinion of consideration.

(1) By using superposed blades the thrust can be greatly increased. (Mr. Walker's experiments have proved this.)

(2) A further increase in the thrust is obtained if aerocurves of the form instituted by Mr. Phillips are employed. [The author is aware that some inventors are using curved blades, but there does not seem to be any uniformity in the attempts.]

(3) A minimum of slip is desirable. (This was shown by Prof. Langley's dynamometer experiments, and also may be deduced from the results of the late Mr. Froude in regard to water.)

Hence it is desirable to run the propeller at only a little above the normal speed of the aeroplane. There is here a difference from marine practice due to the difference between air and water friction. (See Mr. Froude's "Elementary Relations Between Ship, Pitch, and Propulsive Efficiency." Transactions, Institute Naval Architects.) As to the method of transmission of power from the motor to the propeller, this will largely depend on the speed at which the propeller is to run. The Dufaux 120-horse-power set is designed to run at 1,500 R. P. M., but of course a small area and diameter propeller would cause the engine to race until the cross resistance produced a torque equal to that corresponding to the power and speed. If we say that the maximum speed desirable is 60 miles per hour (on a certain machine), and assume a propeller velocity of 65 miles per hour (or 95 1/3 feet per second), we fix the revolutions by the pitch, or *vice versa*. If the motor can efficiently run at the determined propeller speed, then (as is at present usually the case) the shafts will be direct coupled. At present there is scarcely any machine which has the propeller well under control, i. e., can be stopped and started, altered in speed, etc., without stopping the motor. This is due, of course, to the weight of clutches, change speed gears, etc. Probably some of the enterprising firms who have shown an interest in this subject may produce suitable gear for this purpose.

ARRANGEMENT OF SUPPORTING SURFACES.

This problem is the most difficult of all, and is perhaps to us the most interesting, seeing that it is by no means completely solved.

As Major Baden-Powell showed the Society in 1907, the laws relating to the stability of surfaces sustained by the displacement of air are comparatively complex. He quoted the now well-known law of Capt. Joessel as to the displacement of the center of pressure to a position anterior to the center of surface on a plane with a position angle. Kummer and Langley have shown that this displacement is less on planes narrow in the direction of motion, and more on planes long in the direction of motion, than Joessel's law indicates, unless the angle of inclination exceeds 30 deg. Above this angle the relation is reversed. An analogous change takes place in the pressures on the planes. This eccentricity of the center of pressure renders an unbalanced simple surface unstable, being subject to a torque = weight × displacement of c. p. from the c. g. If a weight be attached at such a distance from the c. g. that this torque is balanced for that particular wind pressure and angle, the plane is stable, and if the weight can be rapidly adjusted, balance in many positions is possible. This is the principle of the kite tail, and is employed in José Weiss's "Albatross" gliders, which consist of a torpedo or cigar-shaped body, containing a central shaft, along which slides a leaden weight, the supporting surfaces being "pterygoid aerocurves," i. e., wing type curved surfaces.

Mr. Esnault Pelterie's latest machine (March, 1908) seems to consist of a somewhat similar arrangement, but the planes are dihedral (i. e., inclined downward toward the central body).

Another method of balancing is to use two surfaces separated by a sufficient space to prevent mutual disturbance of the air currents. The pressure on the two surfaces causes a balance (in steady motion) about a point between the surfaces. This again leads to a type of machine. Langley's aerodrome, Bleriot's new machine, and Messrs. Mangin and Gastambide's aeroplane, all show this feature. Laterally, they consist of dihedrally arranged planes, and longitudinally, a pair of similar sets.

The superposed type, and cellular or box type, next call for attention. The superposed type gives additional lift, without increase of length, and is, in the case of the Phillips machine, carried almost to its

limit. The cellular type owes its efficiency to the impressing of a definite course to the current, and so decreasing the variability of the pressure.

Finally we come to a compound type, which has been the source of the French types, which lately have proved successful, viz., the Chanute glider. This consists of a longitudinally-paired but unequal system of superposed and cellular sets. In front we have two superposed planes attached by means of a central girder to a rear cellular set. This arrangement possesses remarkable stability. A method of constructing such a glider was described by Messrs. Voisin Frères in Knowledge last year. A collaboration between Mr. Octave Chanute and Capt. Ferber, furthered by the individual enterprise of Messrs. Voisin Frères, caused several machines to be evolved from the Chanute glider. Among these the Bleriot-Voisin, Archdeacon-Voisin, Farman-Voisin, and Delagrange-Voisin machines are best known. The last two now hold the record for aviation.*

On the basis of these preliminary types, the author has worked a scheme of classification, as follows:

Longitudinal arrangement.

1. Paired sets.—(*a*) Anterior and posterior equal—e. g., Archdeacon, Phillips I, Langley, Ludlow, Bleriot; (*b*) Anterior set larger than posterior set—e. g., Farman, Delagrange, Ferber, Santos Dumont XIX, Chanute; (*c*) Posterior set larger than anterior set—e. g., Santos Dumont XIV *bis*, Roe.
2. Single set.—e. g., Weiss, Vuja, Esnault-Pelterie, Wright brothers.

Vertical arrangement.

1. Superposed planes for both sets.—e. g., Phillips, Bleriot, Ludlow, Bellamy.
2. Superposed anterior set, cellular rear set—e. g., Chanute, Farman, Delagrange.
3. Cellular anterior set, cellular rear set—no examples.
4. Cellular, both sets—Archdeacon, Santos Dumont XIV *bis*.
5. Single planes for both sets—Langley, Bleriot VII.
6. Front set single, rear superposed—Roe.

Lateral arrangement.

1. Dihedral—e. g., Santos Dumont XIV *bis* and XIX, Ludlow, Esnault-Pelterie, Langley, Vuja, Mangin and Gastambide.
2. Monoplanar—e. g., Farman, Ludlow (combined with Dihedral "Tetrahedral"), Archdeacon, Bleriot, Roe.

Form of planes.

1. Uniplanar—e. g., Maxim, Langley, Wright brothers, Archdeacon, etc.
2. Curved—e. g., Phillips, Farman, Vuja, Delagrange.

By means of this scheme it is possible to draw up a specification of the supporting surfaces for any machine. The majority of the machines referred to have made flights of a more or less satisfactory kind, and in the present state of knowledge it is difficult to say which of the types is the best. The Farman-Voisin machine certainly has given the best results to the present, and it is noteworthy that the new Delagrange-Voisin machine, built on exactly the same lines, is equally efficient.

It will perhaps be useful to give the specification of this type (see table).

Longitudinally paired, front set two superposed planes, slightly curved. Posterior set cellular, and smaller than their front set. Both sets laterally monoplanes. Framing consists of two transverse lattice girders united by one axial girder. Propellers between the sets, and aeronaut's car between the superposed planes. [Steering planes will be referred to later.] The center of gravity will lie somewhere near the motor (at the back of the superposed planes), so that the pressure on the rear set × distance from the c. p. of that set to the common c. g. = pressure in front set × distance from c. p. to the common c. g., thus assuming initial balance.

Against the assumption that this is the best type the following facts must be set:

(1) Langley's aerodromes gave very satisfactory results with a much simpler system of planes.

(2) All the more recent machines (including Farman II, Santos Dumont XIX, Bleriot VII, Mangin and Gastambide, Esnault-Pelterie) incline toward the Langley dihedral type.

(3) There is apparently little reserve of lateral stability.

The final choice seems to rest between the Farman-Chanute glider and the Langley dihedral type. In favor of the former are the superposed surfaces the use of which decreases the length and spread of the machine. The latter has the advantage of equal balance and less interference with the action of the rear set. Certainly if the sets are unequal the front should be the larger, so that the center of gravity of the machine should be nearer to it than to the rear. If the sets are equal then superposed or cellular types must to some extent reduce the lift on the rear set. As to steering planes we have several varieties:

1. *Separate sets for vertical and lateral steering.*—In this case approximately horizontal planes (or one plane) are placed in front for vertical steering and a vertical plane or planes for lateral steering at the rear. The axes of vibration lie in a median plane. Examples—Farman I, Wright brothers.

2. *Cruciform set.*—Vertical and horizontal planes intersecting one another at right angles are used in the Langley, Bellamy, and Ludlow machines.

3. *Cellulose set.*—A single box set revolvable about an axis placed in front. This was used in Santos Dumont XIV *bis*, but does not seem to have been regarded by him or other aviators as satisfactory. Capt. Ferber considers it should have been placed in the rear of the machine.

4. *Single large plane.*—Mr. A. V. Roe, in 1907, showed some models in which steering (both vertical and horizontal) was performed by the rear or front set of a paired system consisting of a single plane. This could be rotated through a small angle about a horizontal axis through the center of pressure for vertical steering, and twisted (up one side and down the other on a diagonal) for lateral steering. His large machine at Brooklands (1908) is constructed with the front set arranged in this way. The motor is placed just in front of the rear set (two superposed planes), and the aeronaut's car in under the front plane.

5. *Small planes at tips of dihedral planes* are used in the last Bleriot machine on the front set only, revolvable about axes passing through dihedral planes.

(To be continued.)

* This was written before the recent records made by the Brothers Wright.

TABLE OF MACHINES.

Name.	Longitudinal.	Lateral.	Vertical.
Maxim	Single	Dihedral	Superposed
Langley	Equally paired	Dihedral	Monoplanar
Santos Dumont XIV, *bis*.	Unequally paired	Dihedral	Cellular
Santos Dumont XIX	Single	Dihedral	Monoplanar
Farman I	Unequally paired	Uniplanar	Superposed
Farman II	Multiple	Dihedral	Monoplanar
Delagrange I	Equally paired	Uniplanar	Superposed
Delagrange II	As Farman I		
Bleriot-Voisin I	Unequally paired	Uniplanar	Superposed
Bleriot VII	Equally paired	Dihedral	Monoplanar
Esnault-Pelterie	Single	Dihedral	Monoplanar
Archdeacon	Equally paired	Uniplanar	Superposed and cellular
Mangin and Gastambide	Paired	Dihedral	Single
Roe	Unequally paired	Uniplanar	Superposed
Moore-Brabazon	Paired	Uniplanar	Superposed
Phillips I	Paired	Uniplanar	Superposed
Ludlow	Equally paired	Uniplanar and dihedral	Superposed
Bellamy	Equally paired	Uniplanar	Superposed
Wright brothers	Single	Uniplanar	Superposed
Howard	Single	Dihedral	Monoplanar
Kapferer	Unequally paired	Uniplanar	Superposed
Weiss	Single	Uniplanar	Monoplanar
Types.			
Langley	Equally paired	Dihedral	Monoplanar
Chanute	Unequally paired	Uniplanar	Superposed and cellular
Archdeacon	Equally paired	Uniplanar	Cellular
Penaud	Single	Dihedral	Monoplanar

WHEN IS A CORD OF WOOD NOT A CORD?

TO THE farmer harvesting his small woodlot and to the man laying in logs for the large fireplace of his country or seaside home; to the paper manufacturer buying pulpwood and to the proprietor of the ordinary city wood yard—to all of these men this question has an important dollar-and-cents meaning.

Queer to say, and contrary to the belief of most people, there are many times when a cord is less than a cord, and many conditions when it is more. School arithmetics say that a cord of wood is 128 cubic feet, or the contents of a pile eight feet long, four feet high, and four feet wide. Wood is marketed on this basis. A pile whose length, breadth, and height multiplied together give this number of cubic feet fills this requirement, no matter whether the sticks are long or short, straight or crooked, round or split, unless there is an understanding to the contrary. Nevertheless, a cord, though it comes up to legal measurements, is an uncertain quantity, even when the seller is honest and the buyer satisfied.

A lumberman may have a tract of pulpwood which he sells to a paper mill at $5 a cord, for as many cords as it will make. It is in the contract that he shall cut and stack it. He cuts it in 12-foot lengths, and when the job is complete, it measures 200 cords, and he receives $1,000 for it. Would he have made or lost by cutting 4-foot lengths instead of 12?

He would have lost in the first place from the additional labor required to cut 4-foot wood, but his principal loss would have resulted from a greatly diminished number of cubic feet, due to the fact that short sticks lie closer together than large.

Measurements and experimental tests have been made to ascertain exactly how much actual wood is in cords of different lengths, sizes, shapes, and species.

Had the 200 cords of 12-foot wood been cut in 4-foot lengths, there would have been only 176 cords, and the owner would have received for it $880 instead of $1,000. It was, therefore, clearly to his advantage to cut 12-foot lengths, but it would have been to the buyer's advantage to have it cut in 4-foot lengths. He would have received the same actual quantity of wood for $120 less.

It also makes considerable difference to the seller whether wood is chopped or sawed. If chopped, the chips are lost. Where the logs are large this loss amounts to no small total. In a cord of 4-foot wood, with sticks 6 inches in diameter, the chip loss is from six to eight per cent; and of course the shorter the sticks are cut the greater the loss. If the wood is sawed, the sawdust loss is scarcely the half of one per cent.

The difference due to spaces between the sicks of course depends very much on the shape and size of the sticks. Straight, smooth sticks lie close together, and a cord contains more wood and less air. For given lengths, sticks of soft woods are usually straighter and smoother, and when stacked lie closer together. But whatever the kind, cords of long sticks are pretty sure to contain more empty space than cords made of short pieces. Likewise, cords of split wood contain less than cords of round sticks. The finer the wood is split the more it makes. Hence wood dealers are often willing to sell kindlings, all sawed and split, for the same price per cord as unsplit wood. They get back the cost of labor in the increased bulk.

A cord (128 cubic feet) of 4-foot hardwood usually contains about 83 cubic feet of solid wood; a cord of 3-foot wood averages 83½ cubic feet; of 2-foot wood, 84 feet, and of 1-foot wood 85 feet. The conifers, softwoods, contain 90 to 96 cubic feet. Thus the purchaser receives on an average about two-thirds of a cord of real wood and one-third of a cord of spaces.

In some countries wood is bought by weight, and the buyer comes more nearly getting what he bargains for; but even then he may miss it if he receives green wood when he wants dry. According to timber testing engineers of the United States Forest Service, wood may lose half or more its green weight in seasoning. Cedar for lead pencils is bought by weight in this country. The pieces are so small and of such irregular size that they cannot conveniently be stacked and measured as cordwood.

The bulk of nearly all woods decreases as seasoning goes on. A hundred cords green will make from 89 to 93 cords when dry. This is a factor of no small importance to dealers who handle large quantities.

Woodlot owners and farmers who have small forest tracts from which they expect to sell cordwood are no less interested than contractors who buy and sell large quantities. It will stand them in hand to know how much difference it makes whether wood is cut long or short, chopped or sawed, whether the sticks are round or split, whether large or small, and whether the measurements are to be made while the wood is green or after it is seasoned.

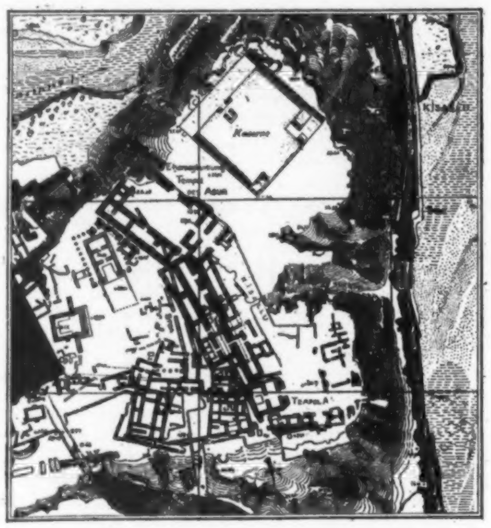
NEW LIGHT ON BABYLON AND ASSYRIA.*

RECENT EXCAVATIONS IN ASSUR AND BABYLON.

BY PROF. MORRIS JASTROW, JR.

For a number of years the German Orient Society has uninterruptedly carried on systematic excavations in two of the most important centers of the ancient Babylonian-Assyrian civilization; in the south in the city of Babylon, which in the days of Hammurabi (about 2000 B. C.) became the capital of Babylonia; and in the north in the city of Assur, the starting point of the political growth of Assyria, now traced back to a period beyond 2000 B. C. Moreover, Assur, even after it yielded its prerogatives to Caleh, and later to Nineveh, still retained considerable of its former prestige. The chief feature of these excavations, conducted in the south by Prof. Robert Koldewey, and in the north by Walter Andreae, is the systematic manner in which the work has been carried on, without sensationalism or blare of trumpets. One section after the other of the extensive mounds at both places has been attacked and thoroughly explored. Indifferent to merely showy results, the explorers have endeavored to obtain as complete a view as possible of the contour of these two capitals in the various periods, and to make an equally complete study of the different kinds of structures unearthed. A great deal of time was devoted to the mere tracing of walls and to other labors that previous explorers, more concerned to announce striking results, would have regarded as wasted efforts. Reports of progress have been sent at frequent intervals to the home office of the society in Berlin, and there published in the form of *Mitteilungen*. The society has had liberal support from a large membership, and in particular from the German Emperor, who has given several thousand dollars annually, and a Berlin banker, James Simon, whose generosity in aiding archæological expeditions has not been limited to the undertakings in Babylon and Assur. The leading spirit of the German Orient Society is Prof. Friedrich Delitzsch, to whom the interest of the German Emperor is largely due. Prof. Delitzsch's lectures on various phases of Babylonian-Assyrian culture, delivered before the German Emperor and repeated in all parts of Germany, have brought the results of Assyriological research to the notice of the general public.

In Babylon, where digging was begun in 1899, one of the chief results was the discovery of the sacred procession street—the *via sacra*—along which the statues of the gods were carried on festivals. It led through the city to the great temple of Marduk, and appears to have been made more particularly for the annual visit which on New Year's day—celebrated at the time of the vernal equinox—the god Nebo, whose seat lay at Borsippa, opposite Babylon, paid to the patron deity of Babylon as a kind of homage to the head of the pantheon. This street, which was raised above the level of the houses, was lined with glazed tiles, on which lions were depicted, accompanying the god on his way. Next to the procession street, the elaborate gateway, likewise leading to the temple and known as the gate of Ishtar, was unearthed and so thoroughly explored that its construction is now known to us in its smallest details. The walls here were likewise covered with glazed bricks, on which dragons and bulls were depicted, which probably represent the designs referred to in one of the visions of Ezekiel. Large portions likewise of the temple area of Babylon were carefully explored, as well as sections



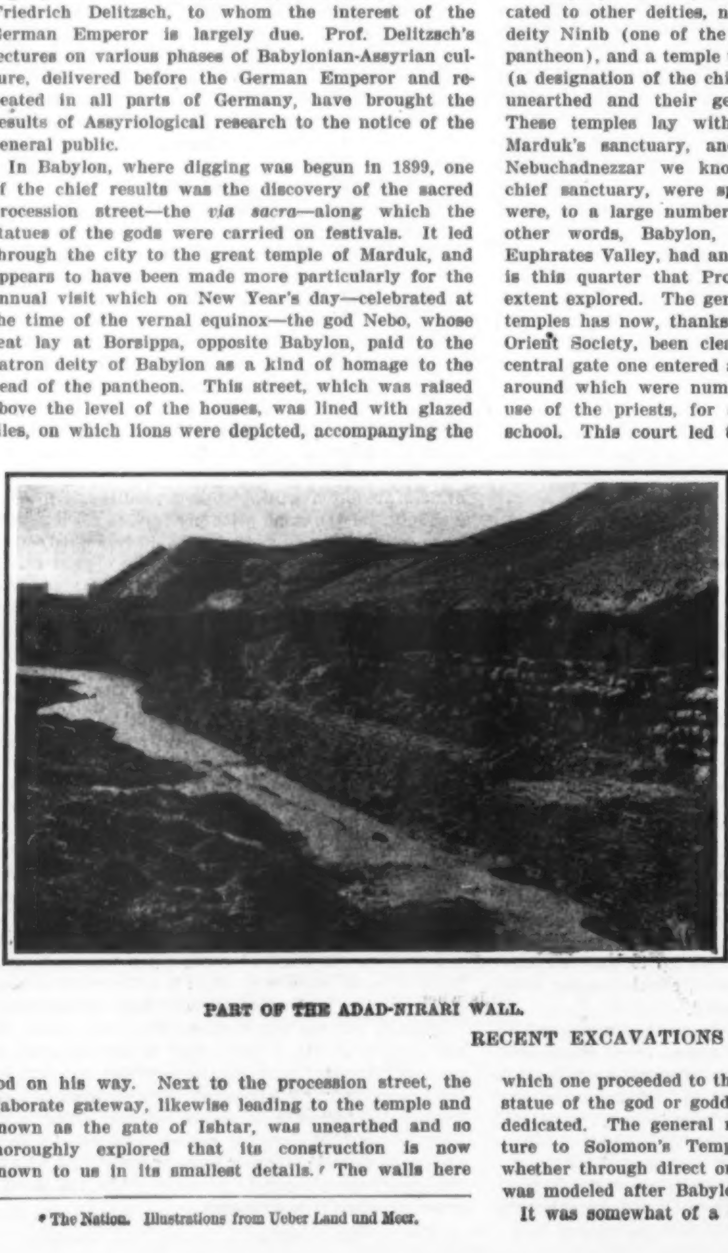
PLAN OF THE NORTHEASTERN PLATEAU.

of the royal palaces, though the almost hopeless state of the ruins afforded less opportunity here for definite results. Besides the great temple of Marduk, known as Esagila, "the lofty house," sacred structures dedicated to other deities, notably a temple to the solar deity Ninib (one of the most important gods of the pantheon), and a temple to Nin-Makh, "the great lady" (a designation of the chief goddess Ishtar), were also unearthed and their general character determined. These temples lay within the sacred area around Marduk's sanctuary, and from the inscriptions of Nebuchadnezzar we know that, grouped about the chief sanctuary, were special edifices, chapels as it were, to a large number of gods and goddesses. In other words, Babylon, like other centers in the Euphrates Valley, had an entire sacred quarter, and it is this quarter that Prof. Koldewey has to a large extent explored. The general character of Babylonian temples has now, thanks to the work of the German Orient Society, been clearly determined. Through a central gate one entered a large court open to the air, around which were numerous smaller rooms for the use of the priests, for storage, and for the temple school. This court led to a smaller inclosure, from which one proceeded to the sacred *cella*, containing the statue of the god or goddess to whom the temple was dedicated. The general resemblance of such a structure to Solomon's Temple leaves no doubt that—whether through direct or indirect copying—the latter was modeled after Babylonian examples.

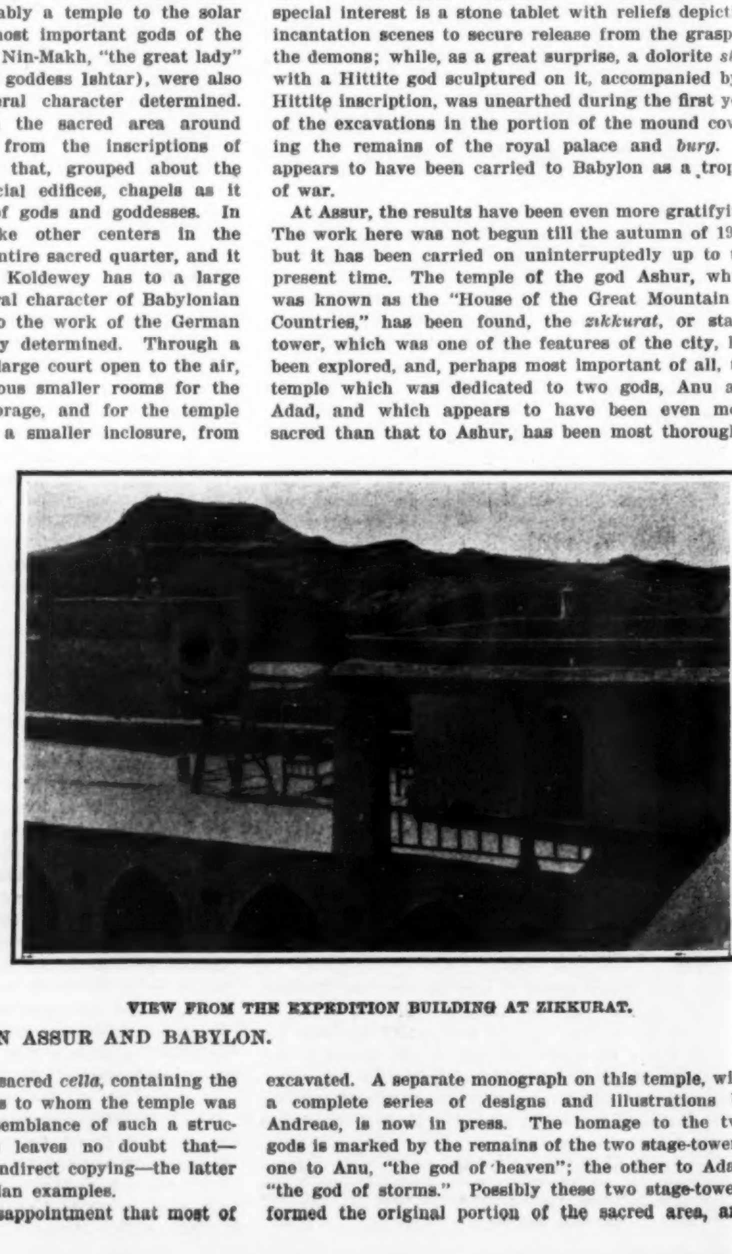
It was somewhat of a disappointment that most of the earlier diggings threw light on only the latest period of Babylonian history, on the time of the Neo-Babylonian dynasty. This was founded in 625 B. C. by Nebopolassar, the father of the famous Nebuchadnezzar, and it lasted only until 539 B. C., when Babylon was taken by Cyrus. The lack of earlier remains was supposed to be due to the sad havoc made by King Sennacherib of Assyria, who, to punish the Babylonians for their frequent revolts against Assyria, destroyed the city in 689 B. C. In order to make destruction complete, he flooded the city. Happily, however, the latest *Mitteilungen* tell of the recovery of a considerable number of cuneiform tablets, chiefly business documents, dated in the reign of the first dynasty of Babylon, the sixth member of which was Hammurabi (about 2000 B. C.). These tablets were found in a stratum of the mounds that reached down to the water level, showing that the explorers had thus struck the beginnings of the settlement. In part, this oldest settlement was built on an eminence at some height above the water. The ancient wall of the city at the old water level has also been traced for a considerable distance; and among other interesting discoveries, mention should be made of the landing places for small boats, to which stairs led down from the wall itself.

To enumerate the many inscriptions and fragments of monuments found in the course of the excavations would carry us too far. Clay cylinders of various rulers, notably one of Nebopolassar, have furnished many new details; a boundary stone dating from the twelfth century contains some important symbols, while terra-cotta statuettes representing the goddess Ishtar, in various forms, among others with a child at her breast, are examples of the kind of votive offerings that the worshipers deposited in the temples. Of special interest is a stone tablet with reliefs depicting incantation scenes to secure release from the grasp of the demons; while, as a great surprise, a dolorite *stele* with a Hittite god sculptured on it, accompanied by a Hittite inscription, was unearthed during the first year of the excavations in the portion of the mound covering the remains of the royal palace and *burg*. It appears to have been carried to Babylon as a trophy of war.

At Assur, the results have been even more gratifying. The work here was not begun till the autumn of 1903, but it has been carried on uninterruptedly up to the present time. The temple of the god Ashur, which was known as the "House of the Great Mountain of Countries," has been found, the *zikkurat*, or stage-tower, which was one of the features of the city, has been explored, and, perhaps most important of all, the temple which was dedicated to two gods, Anu and Adad, and which appears to have been even more sacred than that to Ashur, has been most thoroughly excavated. A separate monograph on this temple, with a complete series of designs and illustrations by Andreae, is now in press. The homage to the two gods is marked by the remains of the two stage-towers, one to Anu, "the god of heaven"; the other to Adad, "the god of storms." Possibly these two stage-towers formed the original portion of the sacred area, and



PART OF THE ADAD-NIRARI WALL.



VIEW FROM THE EXPEDITION BUILDING AT ZIKKURAT.

RECENT EXCAVATIONS IN ASSUR AND BABYLON.

* The Nation. Illustrations from Ueber Land und Meer.

subsequently the temple proper was built with the usual large court, surrounded by a series of rooms. Within the court was a sacred well, and beyond, on the northwest side of the court, was a long room, with the statues of the two gods. Of special interest is a portion of the forked lightning, made of gold, the ordinary symbol of Adad. It is a fair presumption that it belonged to the temple statue of the god and was held in one of his hands. The foundation of this temple can now be traced back to the eighteenth century B. C. Another striking result of the excavations was the discovery near the outer wall of the city of a

BUILDINGS OF THE GERMAN EXCAVATION EXPEDITION AT ASSUR, SEEN FROM THE SOUTHWEST.

"festival house" (*bit akiti*) in honor of Ashur, erected by Sennacherib. To this sacred edifice, the statue of the god Ashur was carried from his temple at the time of the new year's festival, celebrated, as in Babylon, in the spring. The new year commemorated the triumph over the monster Tiamat, symbolical of primeval chaos, and the establishment of order in the universe. This deed was ascribed in Babylonia to Marduk, while in Assyria the distinction was claimed for the god Ashur, who, during the duration of the festival, took up his seat in the special "festival house," surrounded by the statues of other great gods. An extensive garden in front of the structure and another in the large court are some of the features meriting special attention. The *cella*, or "holy of holies," was unusually large, evidently serving as the assembly place of the gods on the most sacred occasion of the year.

A feature of the excavation at Assur is the discovery of many private houses, with vaults in which the members of the family were buried. The dwellings of the living thus became also the abode of the dead. Much light has been shed, both upon the interior arrangement of these houses and on the methods of burial. Burial and cremation appear to have existed side by side, and in burial several methods were followed. The body, somewhat compressed, was either forced into a clay sarcophagus, or it was simply laid on the ground, or it was walled in within clay covers. From the large number of such private houses that were excavated, many of the details of the interior arrangement have now become clear. The floors were generally formed of pressed earth, while the courts were, as a rule, paved with pebbles, bits of stones, or bricks. Regular patterns, rosettes and squares, were formed by the combination of the pebbles and little stones. Much care was bestowed on the drainage, and even the simplest houses had at least a gutter to carry off water and refuse to the street canal. The thresholds were made of gypsum slabs, or of brick, and the supports and hinges for the doors were carefully worked out. The streets appear to have been narrow and irregularly laid out, and, at times, the entrance to the houses lay through an alley, running off from the main street. A feature of the houses was the large court adjoining the main room. The approach to the court was from a kind of corridor, leading directly to the main entrance. In this corridor, there was generally a mortar sunk into the ground, and used for crushing the grain. Traces of stairs going to the roof have also been found. The number of rooms naturally varies. An unusually large house that was unearthed had no less than twenty separate apartments, grouped around the central court, including one that served the purpose of a bath-room.

The number of inscriptions of all kinds found in the course of excavations at Assur is very large, and many of them are of great historical importance. While only portions of these inscriptions have been published, the results have already enabled us to carry the history of Assyria back several centuries beyond 1800 B. C., which a few years ago represented the limit of our knowledge. The oldest Assyrian priestly chief now known to us is Ushpia, the founder of the main temple to the god Ashur. His date can be approximately fixed at 2100 B. C.

Besides the work done in Babylon and Assur, the German Orient Society has also undertaken preliminary excavations at other points in the Euphrates Valley, and has carefully examined a variety of promising sites. Scarcely less important than the results in Babylonia and Assyria is the extension of the society's activities to Egypt and Palestine and to the Hittite settlement in Boghaz-Köl in Cappadocia (see the Nation of February 27th, 1908, page 189) and neighboring sites. In Egypt the site chosen was Abusir, where most important discoveries were made, chiefly in the temple of the dead in honor of King Sahure. In Palestine, the ruins of ancient synagogues in Galilee were thoroughly explored, and last spring the site of the ancient city of Jericho was vigorously attacked and important preliminary results attained (see the Nation of February 4th, 1909, page 125).

The rapid growth of the German Orient Society, now numbering more than one thousand members in all parts of the world, is in itself a recognition of the value of the work accomplished, as well as an index of the remarkable interest in archæological research which, during the last fifty years, has so widely extended our knowledge of the past and fairly revolutionized our views of the earliest civilizations.

MIRROR FOR SEARCHLIGHTS AND MOTOR-CAR LAMPS.

EVER since the introduction of searchlights for battleships and coast defense, attempts have been made from time to time to substitute metallic mirrors in place of glass ones, which are unsatisfactory, due to the fact of their being so readily broken by concussion when firing the guns, and that the silvering at the back of the mirror is very liable to blister and leave the surface of the glass.

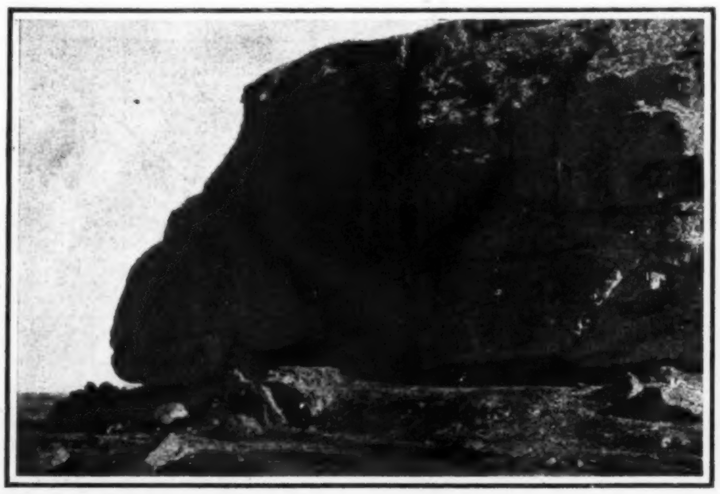
The difficulty of making true parabolic mirrors has been overcome by the Cowper-Coles electrolytic process, which briefly consists of depositing by chemical means on the convex side of a glass former or mold a thin silver film, and then spinning the former in an electrolytic cell charged with copper anodes and a copper electrolyte, so as to deposit the copper on the silver surface, the process being continued until the silver film has reached a sufficient thickness of copper to give the desired rigidity to the finished mirror. The glass mold and the electro-deposit are then removed from the depositing cell and placed in a vessel containing cold water, the temperature of which is gradually raised until the expansion of the copper is sufficient to cause the metallic mirror to leave the glass former. The silver-faced mirror thus produced has as highly-polished a surface as glass. It is finally subjected to an after-treatment to prevent the silver from tarnishing, and is then mounted in a metallic ring (which fits in the projector case) provided with knife edges, which firmly grip the mirror without distorting it. A number of mirrors made by this process have been supplied to the War Office, some of which were sent to the South African war. Mr. Cowper-Coles is now introducing a new metallic mirror which is only partially made by electro-deposition. The mirror has a surface composed of alternate bands or rings of gold and white reflecting surfaces, which it is claimed give a more penetrating beam of light both at night and in foggy weather.

Mr. Cowper-Coles is also introducing a lamp of simple construction for motor cars and railway signals, fitted with a glass or metal parabolic mirror, coated with a yellow metal, which does away with the dazzling effects inherent in silver mirrors, and yet shows up distinct objects more clearly; but, for military purposes, the dazzling effect can be retained.

Objects on which a beam is projected by the Cowper-Coles mirror stand out in greater relief than in a light thrown from a silver white-metal mirror, and the intensity of the light is so great that it is impossible to aim accurately at the projector. Another great advantage of the new mirrors is that they are not fractured by concussion, and even when penetrated by bullets the area of distortion is very small.—Practical Engineer.

WILL ARTIFICIAL SYNTHESIS EVER SUPPLY THE WORLD WITH FOOD?

THE advance in the price of bread recently, due to financial operations which no one can approve, revives in the minds of chemists the possibilities of synthesis when applied to food production. It must be admitted that triumphant as are the very numerous synthetic processes which have been devised by chemists, yet very few of these relate to the building up of food materials from their elements. It is true the sugars have been so fashioned, but how long, laborious, and expensive does the process prove! The most vital constituent of food, the nitrogenous portion, or protein, is a building yet uncompleted by man's effort, although excellent foundations have been laid by the masterly work of Fischer. The simple adjustment of materials in the plant which furnish the important starchy foods is understood to some extent, but no man has been able to imitate it successfully, albeit carbon, hydrogen, and oxygen surround him on every hand. Bricks there are everywhere, but he cannot group them. Yet another important factor in diet is fat, but no chemist has dreamed of a mill which will serve out fat on an intake of grass. The fact is, chemistry succeeds better in the work of destruction than in the work of construction, and analysis must necessarily precede synthesis, so that composition and constitution must first be learned. The forces which determine this composition and constitution are the crux of the whole question, and this is where man is beaten. His food so far can only be produced through the natural synthetic mediums, the plant and the animal; agriculture is a practical matter, but the artificial synthetic factory is not. Will it ever be? There are not a few eminent scientific men who predict with confidence that the world's supply of food (it may be at a distant day) will be produced abundantly and constantly by humanly devised processes which will place questions of quantity on more certain bases than agriculture can promise to do. It is difficult not to be skeptical about such a contemplated consummation of man's ingenuity, and certainly much of the joy and



NORTH POINT OF THE CITY MOUND (SANDSTONE FORMATION).

RECENT EXCAVATIONS IN ASSUR AND BABYLON.

romance of the world would be taken out of it if the rearing of plants and animals ceased to be a necessity of its existence. Still, the triumph which would imply that albumen, starch, sugar, and fat could be fashioned out of the mineral elements, carbon, hydrogen, nitrogen, oxygen, sulphur, and phosphorus, is not beyond the bounds of imagination, only we must not wait for it to put an end to the "cornering" of the people's food.—Lancet.

REFINED ASTRONOMICAL RESEARCHES.

WITH A SIMPLE EXPLANATION OF DOPPLER'S PRINCIPLE.

BY EDGAR L. LARKIN, DIRECTOR OF THE LOWE OBSERVATORY, CALIFORNIA.

If the mighty Newton, returning, could use a late type of telespectro camera, or spectrograph, he would be filled with wonder at the results obtained in these latter days with his early experiments on light. The physicists of the last century would scarcely believe their eyes when looking at a bolometer, to see it measure the one-millionth of a degree of heat.

The writer can scarcely recall any discovery greater or more remarkable than that of binary suns by means of telespectroscopes. The refinement of the manipulation is extreme. The powers of the astro-physicist, watching night after night the tiny rays of light as they come streaming into the slit of the spectroscope, are taxed to their limit. The post of a telespectroscopist is hard to fill. The photography of the incredibly delicate lines in stellar spectra requires the utmost skill, patience, and care.

The most powerful telescope ever made may be set on a close spectroscopic binary, or double star, and not be able to see the two. Even with high-power eyepieces they look like one point, so near are they to each other. But the powerful spectroscopes are able to resolve the one point into two; and not only this, but to detect motions of the two suns around their gravitation center. The times of revolution can be observed, and when the distant suns have a sensible parallax, the distance between them can be determined in miles. With time and distance known, velocities in their orbits follow at once. Then with velocity and distance the mass of both can be computed; that is, both suns can be "weighed" in terms of the mass of our sun. For it is known from the laws of gravity and motion how much matter is required at any given distance, and velocity, to set up centrifugal tendency equal and opposite to gravitation. All these marvels of finding velocities of spectroscopic binaries are based on Doppler's principle, a discovery in the nature of light. The mathematical formulæ are given by Prof. Charles A. Young, "General Astronomy," p. 202. In the entire range of science there are but few things more beautiful or refined. Doppler's principle is that of an apparent shortening and lengthening of waves of light. The effect is as though light waves were actually made longer or shorter. Suppose a person could approach a sounding piano wire at great speed. The sound would rise to a higher key note as he drew nearer. Sound waves would enter the ear in increased numbers, and raise the pitch of the tone. And the key would be lowered if the distance between the ear and wire should rapidly increase. Doppler's law can be demonstrated by standing near a railway when a fast express is approaching. If the bell rings or whistle sounds, their keynotes will rapidly rise and as rapidly fall when the train passes and recedes. Colors in light correspond with pitch in tone. Similar effects obtain in waves of light, if their source approaches or retreats. Spectroscopes detect these changes in light, while a telescope alone cannot. This is because the prism or grating in a spectroscope separates waves of light, and distributes them in their proper positions along the spectrum.

An attempt is here made to explain Doppler's laws. In Diagram I., Fig. 1, *A* is a ray of light from the star *S*, falling on the side of the prism, *P*, which has the property of separating any mixture of light into separate waves. Light from the sun or stars is made up of a vast number of colors, all appearing between the limits red and violet. Had the pencil, *A*, not encountered the glass, it would have passed to *B*. But the prism separates the white light into colors which can be projected on any white surface. The red is invariably bent out of its original direction the least, violet most, and will respectively pass to *R* and *V*, with every other color between. The shorter the waves, the greater their deflection from a straight course. Red waves run 33,000 to an inch and violet 64,000. An eye at *E* would see all the colors between *R* and *V* direct, and at *H* by deflection, if a screen is allowed to receive the light from *R* to *V*. Solar and stellar spectra are crossed at right angles by black Fraunhofer lines. Take any one, say *F*, anywhere in the spectrum and measure its position with a micrometer. Then the eye, either at *E* or *H*, would see a spectrum as outlined in Diagram I., Fig. 2, extending like *R*, 1, *F*, 2, *V*. Now let the prism move at great speed, such as that due to the velocity of the earth in space, toward the star, or the star move toward the earth. Then the line *F* will move to 2, or toward the violet end. But if the earth and star move in opposite directions, the line *F* will move to 1, or toward the red. Mathematicians have found out how fast the prism must move to cause a Fraunhofer line to shift laterally any given distance. This is one of the greatest discoveries ever made. If a star is coming on a straight line toward the earth, moving toward or away from it, the velocity in miles per second can be determined in either case. For if more than the normal number of waves of light are forced through the prism, they will seem to be shorter and therefore bent farther out of their course toward 2; and toward 1 if less waves come streaming in. The telescope, without a prism attached, could not tell whether these stars were at rest or in motion. But

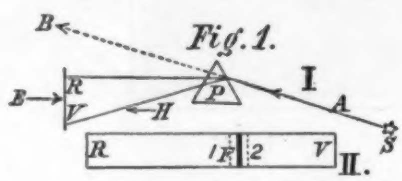


Diagram No. 1.—The pencil of light, *A*, coming from the star, *S*, would pass to *B* if the prism *P* were removed. The glass separates the stellar light into all the colors it may contain. The red rays are bent to *R* and the violet to *V*, forming with the colors between the spectrum of the star.

if any star moves so that it makes an angle with the straight line from the earth to it, then the micrometer in the eye-piece of the telescope can measure the displacement. Such movements are called proper motions, while motions toward or from the earth in a straight line are called motions in the line of sight. There is not a "fixed star" in existence. Every one is a hot sun in rapid motion. The great astro-physical observatories, notably the Lick and Yerkes in the United States, and of Potsdam in Germany and Greenwich in England, have made extensive explorations in the line of sight. Here is a table giving a few stars selected almost at random.

MOTIONS OF STARS IN THE LINE OF SIGHT.

Names of Stars Approaching.	Miles per Second.	Names of Stars Receding.	Miles per Second
Alpha Arietis	12	Aldebaran	31
Gamma Leonis	25	Betelgeuse	18
Spica	11	Rigel	14
Altair	24	Capella	30
Polaris	12	Alpha Coronæ	20
61 Cygni	27	Eta Pegasi	3
Procyon	7	XI. Piscium	19
Arcturus	5	Epsilon Hydræ	30
Beta Herculis	30		

These are all colossal suns. Their speeds are great; for one cannot realize what a velocity of one mile per second—sixty times faster than a fast train of cars "here on earth"—really is. Our star, the sun, moves about 12.5 miles per second, and drags us along with it, keeping exact time and distance. There is no danger of the earth being left in the rear to freeze in the solitudes of interminable space at the absolute zero.

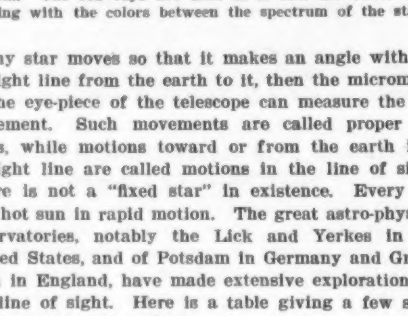


Diagram No. 2. A Binary.—In this cut *S* is the place of the more massive sun, far and away to one side of the center of the orbit. The orbit and four portions of the revolving sun are represented by *A*, *C*, *P*, *G*. The two parallel lines *C E* and *G F* point toward the earth. When the moving sun is at *C*, coming toward the earth, the line *L* will shift to 2 in Cut No. 1; and when at *G*, going away from the earth, the line *L* will move to 1, toward the red.

When two suns revolve in regular orbits around their common center of gravity, they are known as binary stars. Many binary systems were discovered with telescopes before spectroscopes were attached to them. The great triumph of the spectroscope is that its serviceability is far greater than that of the unaided telescope, owing to its ability to analyze the light brought into it by the great object glass. The Doppler principle applied to the discovery of binaries is shown in Diagram II., where *S* is a sun, far and away to one side of the center of the orbit of its companion, as shown in four positions *A*, *C*, *P*, *G*. Few systems have circular orbits, and the eccentricity is very great in a majority. As seen from the earth when at *G*, the flying sun will send fewer waves per second into the spectroscope, and the Fraunhofer lines will shift toward the red, in Diagram I., Fig. 2. The point *A* is apastron, and *P* periastron. The velocity of the revolving sun at *P* in its orbit is enormous; while the light and heat of *S* are intolerable to the people on any planet revolving around the sun *P*. For if either sun has a retinue of worlds like the earth, with inhabitants, their changes of climate are extreme. While the flying sun is moving from *A* through *C* and around to *P*, Diagram II., the huge sun *S* rapidly increases its apparent diameter, and also its light and heat. After passing *C* in the direction of the arrows, *S* must look like a blazing globe in skies of incandescent brass. In the revolution of a planet around either sun it would move in between them. There would be no night. The world and its people would be between two white-hot suns. Life would expire; but if by chance a few of the inhabitants survive the passage through *P*, they would freeze when their sun reached the distant point *A*. Therefore all binaries having great eccentricity of orbits are utterly worthless for support of life on their planets if they have any. All planets are invisible from space, whence it follows that the inhabitants of stellar spaces have not heard of the earth yet. Kepler found that the "squares of the times of revolutions of all the planets around the sun are as the cubes of their mean distances from it." Let us try this law on a binary. The mass of our sun, the earth's distance from it, and the time of its orbital revolution, each is equal to 1. And the square and cube of 1 each equals 1. Our nearest neighboring sun is Alpha Centauri and is a binary. The revolving sun is at a distance from its central sun of 21.33; the time required to make a revolution is 81, and knowing these values, both can be "weighed." The cube of $21.33 = 9{,}664$, and the square of $81 = 6{,}561$. Therefore, the quantity of matter in both suns is to the quantity in our sun and earth as the ratio of this cube and square. And $9{,}664 \div 6{,}561 = 1.5$; so the binary is one and one-half times more massive than the masses of the sun and earth combined.

But the distance of the revolving sun from the larger, 21.33, was employed. This 21.33, to reduce to miles, must be multiplied by 93,000,000, the distance of the earth from the sun. But suppose we do not know the distance from the earth to the two stars, and therefore do not know their distance apart. How proceed to find the mass of the distant binary? No great achievement has been wrought that will compare with the abstruse problem of finding the quantity of matter in a binary system without knowing its distance. Surely this is beyond the power of man! No; Doppler's laws of light enable mathematicians actually to solve this mighty problem of all time. Lateral displacements of the Fraunhofer lines, as in Diagram I., Fig. 2, have a fixed ratio to velocities of approach and recession. Suppose an astro-physicist on this speck of dust, the earth, far away in the direction of the arrows, say 100 or 200 trillion miles—it makes no difference which, provided light from the stars reaches the earth in quantity sufficient to form a spectrum whose lines can be measured—wishes to find how much matter the two suns in Diagram II. contain. He sets the telespectroscope on the pair, night after night, and measures with extreme accuracy the shifting of the lines, now toward the red and then the violet (Diagram I., Fig. 2). He does not see the stars in the instrument, but their spectra only—tiny, delicate, and beautiful bands made up of a few colors and black lines. But he watches the lines with great care when the moving sun is at *C* and *G*, and measures their displacement with the micrometer. By repeated observation, he finally learns a thing of vast import, the speed of the sun's revolution in its orbit. And this entirely by means of the known relation between shifting of spectral lines and the speeds of the flying sun at times of approach and recession. And by direct observation he notes the time of one revolution. He multiplies velocities per second by the number of seconds, and thus finds the circumference and radius of the orbit. He at once knows how many times farther apart the two suns are than our sun and earth. Then

it becomes simple arithmetic to apply Kepler's law and find mass.

DESCRIPTION OF SEVERAL BINARIES.

Of such extreme delicacy is the modern telescope and spectrograph, that slight displacements can be detected. Thus, suns are known to move one way and then the other under the attraction of vast dark, invisible masses. Prof. W. W. Campbell, of the Lick Observatory, detected two bright suns making revolution, while the orbits were disturbed by a third but unseen body. The bright suns revolve in a period of 3d. 23h. 15 m.; and the entire system is called Polaris, our present north polar star. For centuries telescopists thought Polaris to be one star. It is rushing toward our sun and earth with a velocity of about 15 miles per second. In August, 1899, the bright star Capella was discovered by Prof. W. W. Campbell to be a binary from photographs of its spectrum.

The range in velocities of the revolving suns is from 4 to 56 kilometers per second for the more massive, and from 3 to 63 kilometers for the secondary. The period of revolution is 104 days, while the speed of the center of mass of the system is 30 kilometers per second, a velocity almost precisely that of the earth on its orbit around the sun. A wide range exists in periodic times, velocities of revolution around each other, and through space, of the known binaries. Many of these, having moderate eccentricities of orbits, if surrounded by habitable worlds would present varying scenes of splendor to any rational inhabitants; for a number are of different colors and temperatures. Skies would vary in color with the particular sun that might be above the horizon while "sunset glows" would change colors also with succeeding suns.

SPECTROSCOPIC BINARIES.

Names.	Periods in Days.	Orbital Velocities. Miles per Second.
Mu Scorpii	1.45	144
Pi Scorpii	1.57	
Delta Orionis	1.91	44.5
Beta Persei	2.87	25.8
Castor (1)	2.91	7
A. G. C. 10,534	3.12	190
Beta Aurigæ	3.98	75
Pole Star	3.98	2
Spica	4.01	57
Delta Cephei	5.37	13
Eta Aquilæ	7.18	13.4
Zeta Geminorum	14.15	8.2
Beta Lyræ	10.20	30
Lambda Andromedæ	20.00	5
Capella	104.00	18
Beta Herculis	412.00	8
Eta Pegasi	818.00	9
Beta Capricornii	1,000.00	

This table shows a range of from forty-five hours to three years. The list might be greatly extended, with ever-increasing sublimity and grandeur.

PETROLEUM SOAPS.

ALTHOUGH mineral oils differ greatly in chemical character from animal and vegetable oils and do not readily combine with other substances, attempts have been made to utilize them in the manufacture of soap and some interesting results have been obtained. The soaps produced are of three kinds: mixed soaps, naphthenic acid soaps, and hydrocarbon soaps.

Mixed Soaps.—After the failure of many attempts to saponify mineral oils, directly or indirectly, with the aid of the most powerful chemical agents, mixtures of petroleum and fats were treated with alkalies by various processes, or petroleum was added after saponification of the fat, the formation of an emulsion being facilitated by adding a little rosin. Until a few years ago the largest proportion of petroleum thus incorporated with soap was only 15 per cent. Lothammer and Troquenet have recently increased the proportion to 40 per cent or more by first emulsifying a heavy petroleum oil with extract of soap bark. The mixture, which has the consistency of butter, is then mixed with palm oil and heated several hours before the soda lye is added. These mixed soaps are mere emulsions of soap with petroleum. The mineral oil adds nothing to their detergent power but it does not injure the textile fibers, and makes it possible to use very hard water and facilitates some operations.

Naphthenic Acid Soaps.—Naphthenic acids are found in proportions of ½ to 1 per cent in the heavy oils obtained from Russian petroleum. Their boiling points range from 480 to 700 deg. F. They are obtained in large quantities by the action of mineral acids on the lye with which petroleum has been washed in the refining process. The mixture of crude naphthenic acids thus obtained is a very dark-colored mobile liquid of specific gravity 0.965, which distills without much decomposition at temperatures below 680 deg. F., and combines readily with alkalies, forming a soft soap. A hard, compact soap is produced by saponifying a mixture of 3 parts of naphthenic acids and 1 part of palm oil or animal fat. The soap-making process is necessarily modified by the remarkable solubility of alkaline naphthenic soap in salt water.

Naphthenic soap is already used extensively in Russia; although its employment is limited by its disagreeable odor, which it appears impossible to remove. On the other hand, it is a valuable disinfectant, as the naphthenic acids have been proved to exert a powerful germicidal action. They may advantageously be added in proportions of 3 to 5 per cent instead of carbolic acid or creosote, to ordinary hard olein soaps. A stronger disinfectant is made by mixing one part of the acids with 4 parts of soft potash soap.

Hydrocarbon Soaps.—Zelnisky has succeeded in converting the saturated hydrocarbons of naphtha into compounds capable of saponification. The experiments have not yet passed the laboratory stage but their importance makes them worthy of mention. The portion of petroleum which distills between 240 and 248 deg. F. is first converted into a mixture of the chlorinated compounds $C_9H_{17}Cl$ and $C_9H_{15}Cl$. The action of magnesium on an ethereal solution of these compounds produces $(C_9H_{17})_2Mg$ and $(C_9H_{15})_2Mg$, which are converted by the action of carbon dioxide into $(C_9H_{17})_2Mg(CO_2)_2$ and $(C_9H_{15})_2Mg(CO_2)_2$. The removal of the magnesium by mineral acids from these complex substances leaves the compounds $C_9H_{17}COOH$ and $C_9H_{15}COOH$, which are chemically analogous to the fatty acids and capable of saponification in the ordinary manner.

Correspondence.

TWO MAGIC SQUARES.

To the Editor of SCIENTIFIC AMERICAN SUPPLEMENT:

I have followed with interest your columns of "Curiosities of Numbers," and note that not many articles treat on magic squares, etc. Although the latter might better be called "Curious Arrangements of Numbers," they are both treated as mathematical recreations, and are generally known under that head.

If you can spare room in your columns, I think the following two magic squares will be of interest to many.

The first is a square of 15^2 cells, composed of nine equal series of numbers, each series being 1, 2, 3, 4, . . . 25. They are arranged so that any row of fifteen numbers, horizontally, vertically, or diagonally, will add to 195.

The main feature of this square is that a square may be drawn anywhere within the main square that will inclose 25 numbers, and those numbers will be the series 1, 2, 3, 4 . . . 25, arranged in a perfect magic square with its horizontals, verticals, and diagonals each adding to 65. Two of such squares are shown in the illustration.

Also, any square of 25 numbers, of the arrangement shown in heavy type, holds the same conditions mentioned above.

The second is a square of 27^2 cells composed of the series 1, 2, 3, 4 . . . 729, arranged so that the horizontals, verticals, and diagonals each add to 9,855. Let this square be equally divided into nine smaller squares, and each will be a perfect square having its horizontals, verticals, and diagonals adding to equal amounts. Now, let each of these squares be divided into nine smaller squares, making a total of 81 squares of nine numbers each; and each will be a perfect square with an equal sum for its horizontals, verticals, and diagonals.

This square also contains hundreds of other magic squares, of which the following are a few:

(a) 254, 299, 290, 317, 281, 245, 272, 263, and 308.
(b) 254, 704, 128, 236, 362, 488, 596, 20, and 470
(c) 578, 218, 290, 74, 362, 650, 434, 506, and 146.
(d) 92, 542, 452, 722, 362, 2, 272, 182, and 632.
(e) 632, 232, 312, 72, 392, 712, 472, 552, and 152.
(f) 416, 542, 128, 74, 362, 650, 596, 182, and 308.
(g) 191, 241, 177, 189, 203, 217, 229, 165, and 215.
(h) 254, 259, 258, 261, 257, 253, 256, 255, and 260.

In the large square and in any magic square found in the large square, the sum of any pair of numbers directly opposite and equidistant from the center number, is equal to twice the center number, as:

In the square (a) $317 + 245$ or $254 + 308 = 2 \times 281$.
In the square (c) $218 + 506$ or $290 + 434 = 2 \times 362$.
In the square (g) $191 + 215$ or $189 + 217 = 2 \times 203$.

The squares (d) and (e) possess another curiosity; that is, each of their numbers has 2 for its unit figure. There are no less than eighteen squares of this nature contained in the large square.

With a little study, the methods of construction of the two foregoing squares are easily detected.

Schenectady, N. Y. HARRY A. SAYLES.

4	23	17	11	10	4	23	17	11	10	4	23	17	11	10
12	6	5	24	18	12	6	5	24	18	12	6	5	24	18
25	19	13	7	1	25	19	13	7	1	25	19	13	7	1
8	2	21	20	14	8	2	21	20	14	8	2	21	20	14
16	15	9	3	22	16	15	9	3	22	16	15	9	3	22
4	23	17	11	10	4	23	17	11	10	4	23	17	11	10
12	6	5	24	18	12	6	5	24	18	12	6	5	24	18
25	19	13	7	1	25	19	13	7	1	25	19	13	7	1
8	2	21	20	14	8	2	21	20	14	8	2	21	20	14
16	15	9	3	22	16	15	9	3	22	16	15	9	3	22
4	23	17	11	10	4	23	17	11	10	4	23	17	11	10
12	6	5	24	18	12	6	5	24	18	12	6	5	24	18
25	19	13	7	1	25	19	13	7	1	25	19	13	7	1
8	2	21	20	14	8	2	21	20	14	8	2	21	20	14
16	15	9	3	22	16	15	9	3	22	16	15	9	3	22

The quantity of mineral matter in India rubber can be determined as follows: The specimen is first extracted with acetone. One part of the residue is immersed in about 50 parts of xylol in a stoppered glass vessel which is placed in an autoclave containing xylol. The temperature is raised gradually so that the pressure rises to 15 atmospheres in about half an hour. The heating is continued under a pressure of 15 to 18 atmospheres for three or four hours, and the autoclave is allowed to cool before it is opened. The solution in the glass vessel is then diluted with an equal volume of ether and filtered through weighed filter paper, which, with the precipitate, is washed with ether, dried, and again weighed.

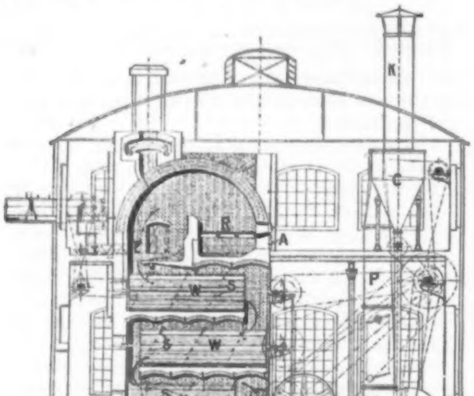
92	497	416	137	542	461	128	533	452	97	502	421	142	547	466	133	538	457	96	501	420	141	546	465	132	537	456
659	335	11	704	380	56	695	371	47	664	340	16	709	385	61	700	376	52	663	339	15	708	384	60	699	375	51
254	173	578	299	218	623	290	209	614	259	178	583	304	223	628	295	214	619	258	177	582	303	222	627	294	213	618
155	560	479	119	524	443	83	488	407	160	565	484	124	529	448	88	493	412	159	564	483	123	528	447	87	492	411
722	398	74	686	362	38	650	326	2	727	403	79	691	367	43	655	331	7	726	402	78	690	366	42	654	330	6
317	236	641	281	200	605	245	164	569	322	241	646	286	205	610	250	169	574	321	240	645	285	204	609	249	168	573
110	515	434	101	506	425	146	551	470	115	520	439	106	511	430	151	556	475	114	519	438	105	510	429	150	555	474
677	353	29	668	344	20	713	389	65	682	358	34	673	349	25	718	394	70	681	357	33	672	348	24	717	393	69
272	191	596	263	182	587	308	227	632	277	196	601	268	187	592	313	232	637	276	195	600	267	186	591	312	231	636
99	504	423	144	549	468	135	540	459	95	500	419	140	545	464	131	536	455	91	496	415	136	541	460	127	532	451
666	342	18	711	387	63	702	378	54	662	338	14	707	383	59	698	374	50	658	334	10	703	379	55	694	370	46
261	180	585	306	225	630	297	216	621	257	176	581	302	221	626	293	212	617	253	172	577	298	217	622	289	208	613
162	567	486	126	531	450	90	495	414	158	563	482	122	527	446	86	491	410	154	559	478	118	523	442	82	487	406
729	405	81	693	369	45	657	333	9	725	401	77	689	365	41	653	329	5	721	397	73	685	361	37	649	325	1
324	243	648	288	207	612	252	171	576	320	239	644	284	203	608	248	167	572	316	235	640	280	199	604	244	163	568
117	522	441	108	513	432	153	558	477	113	518	437	104	509	428	149	554	473	109	514	433	100	505	424	145	550	469
684	360	36	675	351	27	720	396	72	680	356	32	671	347	23	716	392	68	676	352	28	667	343	19	712	388	64
279	198	603	270	189	594	315	234	639	275	194	599	266	185	590	311	230	635	271	190	595	262	181	586	307	226	631
94	499	418	139	544	463	130	535	454	93	498	417	138	543	462	129	534	453	98	503	422	143	548	467	134	539	458
661	337	13	706	382	58	697	373	49	660	336	12	705	381	57	696	372	48	665	341	17	710	386	62	701	377	53
256	175	580	301	220	625	292	211	616	255	174	579	300	219	624	291	210	615	260	179	584	305	224	629	296	215	620
157	562	481	121	526	445	85	490	409	156	561	480	120	525	444	84	489	408	161	566	485	125	530	449	89	494	413
724	400	76	688	364	40	652	328	4	723	399	75	687	363	39	651	327	3	728	404	80	692	368	44	656	332	8
319	238	643	283	202	607	247	166	571	318	237	642	282	201	606	246	165	570	323	242	647	287	206	611	251	170	575
112	517	436	103	508	427	148	553	472	111	516	435	102	507	426	147	552	471	116	521	440	107	512	431	152	557	476
679	355	31	670	346	22	715	391	67	678	354	30	669	345	21	714	390	66	683	359	35	674	350	26	719	395	71
274	193	598	265	184	589	310	229	634	273	192	597	264	183	588	309	228	633	278	197	602	269	188	593	314	233	638

THE TECHNIQUE OF DESICCATION.

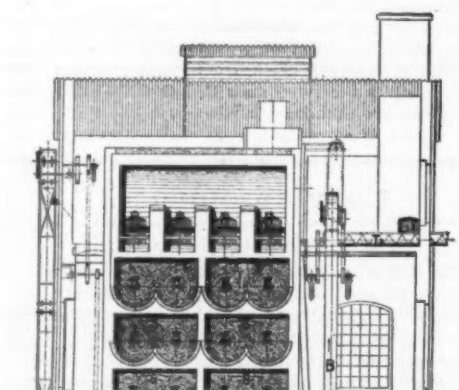
THE ARTIFICIAL DRYING OF AGRICULTURAL PRODUCTS AND WASTES.

BY O. BECHSTEIN.

DRYING is the oldest and best method of preserving vegetable substances, but until recently it was applied only to a few agricultural products, particularly to grass, clover, grain, and straw, and, to a limited extent, to fruit, and was effected solely by exposure to the sun and air. Now, however, the farmer has at



LONGITUDINAL SECTION.



TRANSVERSE SECTION.

FIGS. 1 AND 2.—BUETTNER AND MEYER APPARATUS FOR DRYING SPENT BEET CHIPS.

his disposal a variety of methods and apparatus for the artificial drying of all crops and the conversion of waste products into useful and marketable commodities that can be kept indefinitely.

In 1884, the German association of beet sugar manufacturers offered a prize of 15,000 marks for the best method of drying spent beets. In the usual diffusion process the beets are cut into chips and macerated in hot water, which extracts the sugar but not

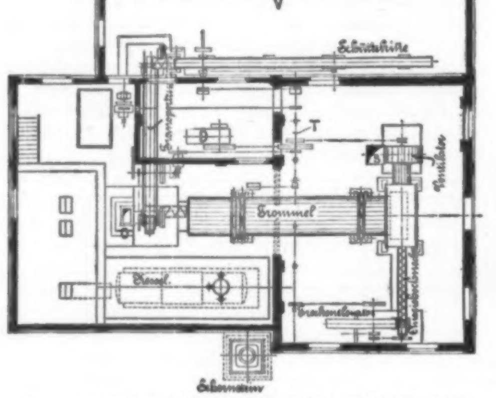


FIG. 3.—PLAN OF BUETTNER UNIVERSAL DRYER.

Schüttelrinne = chute. Transporteur = conveyor. Trommel = drying cylinder. Ausziehschnecke = conveyor. Trockenelevator = conveyor.

the albuminoids and other nutritious constituents. But the spent chips, even after they have been pressed, contain 85 to 90 per cent of water. In this condition they are sold as cattle feed, but they are apt to cause serious disease when given in large quantities. They are still more unwholesome after they have been kept in silos, an expedient made necessary by their rapid accumulation in the short season of sugar making, and the loss by fermentation and decomposition some-

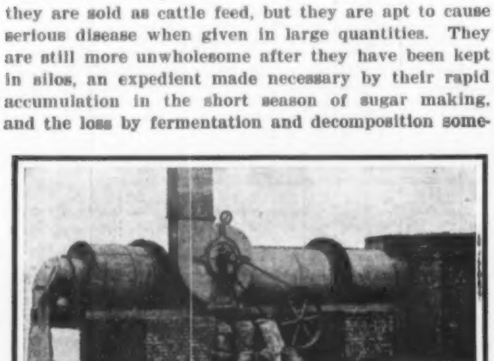


FIG. 3A.—VIEW OF BUETTNER UNIVERSAL DRYER.

times amounts to 50 per cent. Of the 6 million tons of pressed beet chips annually produced in Germany, three-fourths went into the silo. With an average loss of 30 per cent and an average value of $1 per ton, the annual money loss due to fermentation considerably exceeded one million dollars. The cost of transporting fodder which is nine-tenths water is also very great in proportion to its food value.

Yet in four successive years the prize was offered in vain. In 1888 it was awarded to Buettner and Meyer, for a process which has since been generally employed, and by which a perishable and unwholesome material is converted into excellent fodder which can be transported to any distance. Thus sugar makers and beet farmers have been benefited and imports of foodstuffs greatly diminished.

The Buettner apparatus is shown in Figs. 1 and 2. Three superposed rows of cylinders (W) bearing longi-

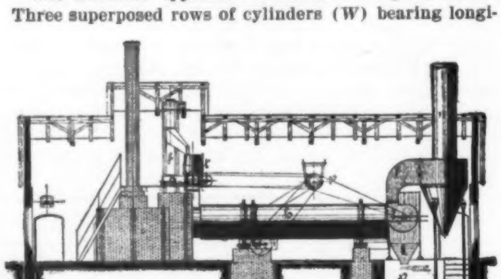


FIG. 4.—LONGITUDINAL VERTICAL SECTION.

tudinal blades or shovels (C) rotate in a brick oven with a sheet iron front. Fig. 1 shows the belts and gearing which transmit power to the cylinders. Above the cylinders is a grate (R) on which fuel is burned. The combustion gases are drawn out of the oven by a blower (V) at the bottom, to reach which they are compelled to pass successively along the three series of cylinders. The wet beet chips are fed into orifices (E), at the level of the grate, by screws (T). They fall on the highest row of cylinders and are pushed along them to their farther ends, whence they fall on the second row, and so on. But, while the general course of the chips is everywhere parallel to that of the gases, they are continually being tossed up by the revolving shovels, so that they are thrown into intimate contact with the hot gases. At the bottom of the oven they fall on a screw (T_1), which conveys them to a chain pump (B), by which they are raised to a screw (T_2), which drives them onward to a storage room. Air is admitted through the door of the ashpit (A) and special valves. The products of combustion, laden with moisture from the chips, pass from the blower (V) through a pipe (B) to a centrifugal dust separator (C) and thence to the chimney (K). The chips are driven along the horizontal cylinders entirely by the stream of gas into which they are continually tossed, for the shovels are so formed that they throw the chips rather backward than forward. Hence the drier chips, being lighter, are carried onward by the current, while the wetter chips lag behind until they also have become dry.

Although the temperature of the gases is at least 1,500 deg. F., the chips are not burned or even heated to the boiling point, owing to the cooling effect of the rapid evaporation, and consequently their digestibility is not impaired. It is this fact, which the inventors had observed in other drying apparatus, that makes the process profitable, by allowing the employment of a very high temperature, with resultant economy of heat. Nor are the chips contaminated in any way, as special devices are employed to insure complete

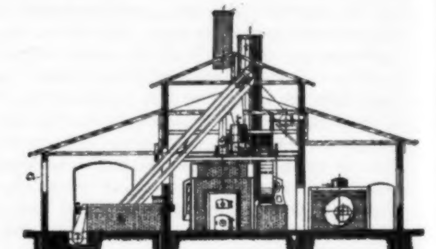


FIG. 5.—TRANSVERSE VERTICAL SECTION.

and smokeless combustion and to eliminate flying ash. Finally, there is no loss in dry weight, as all floating particles are collected by the centrifugal separator and added to the product.

In composition, the dried chips most nearly resemble good hay, but they may also be substituted for grain with advantage. The average digestibility of their protein is nearly 87 per cent, while that of the protein of beet chip ensilage is only 73 per cent. Experiments made in feeding them have been uniformly successful, and as the cost of the process is very small in comparison with the food value of the product the dried chips have rapidly come into favor as fodder for cattle, sheep, swine, and foals. More than 200 sugar houses, in Germany and elsewhere, are now equipped with the Buettner apparatus.

Another important by-product of the manufacture of sugar is molasses, which is also a valuable foodstuff, although inconvenient to transport or to feed

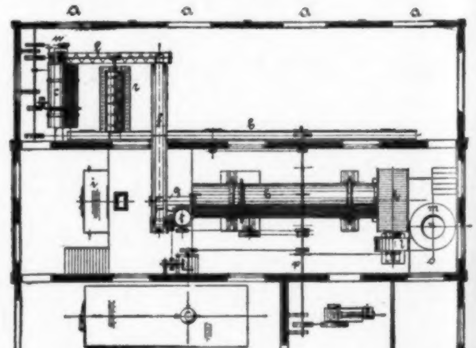


FIG. 6.—PLAN.

directly. In 1892 Wuestenhagen patented a process of spraying beet chips with hot molasses before they are dried. The "molasses chips" thus produced are easily stored and fed, are more nutritious than plain dried chips and have an appetizing odor resembling that of malt.

The artificial drying of beet tops and leaves, which are cut off on the farm and of which 12½ million tons are annually produced in Germany, is of much

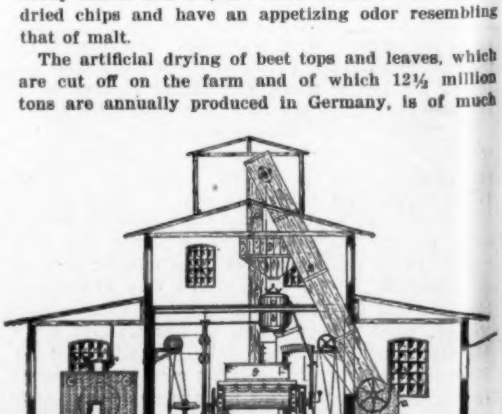


FIG. 7.—VERTICAL SECTION.

more recent introduction. The tops and leaves are sometimes plowed under, but the practice is not advisable as they have little fertilizing value and contain the germs of various diseases which are thus communicated to the succeeding crop. Although their dry substance is nutritious they are of little value as green fodder, as they are five-sixths water.

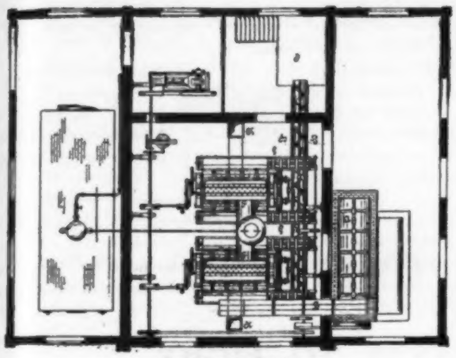


Fig. 8.—PLAN.

When the leaves are wilted and sun-dried in the field the cattle will not eat them freely, and when converted into ensilage they lose much of their food value and are neither well relished nor wholesome.

The artificial drying of beet tops and leaves, on a large scale, was inaugurated in 1900, and each succeeding year has witnessed an increase in the number of drying plants and in the quantity of the new fodder produced. The Buettner universal drier was devised for drying beet leaves but, as its name implies, it is equally well adapted to the desiccation of all agricultural products and many other substances. Fig. 3 shows the plan of the apparatus. From the storeroom (*V*) the leaves pass down a chute to a cutter (*R*), whence a conveyor carries them to the mouth of the drying cylinder. Combustion gases, generated in the furnace *O* and mixed with air, enter the cylinder with the chopped leaves. The cylinder, which is turned slowly by the steam engine *D*, contains a series of partitions by which the leaves are kept in continual motion and brought into intimate

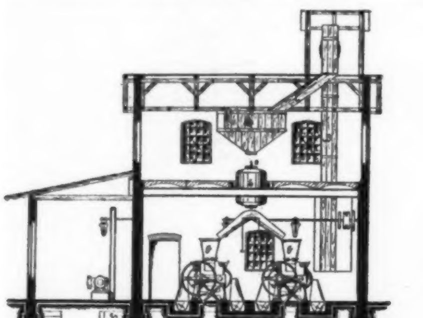


Fig. 9.—VERTICAL SECTION.

contact with the hot gases. Scorching and overheating are prevented, as in the chip dryer, by rapid evaporation. From the farther end of the cylinder the dried leaves are removed by a screw conveyor, which either pours them into bags or delivers them to another conveyor, which forwards them to a storeroom. The gases are drawn through the cylinder by an exhaust blower and escape through the chimney *S*, after traversing a centrifugal separator, which retains all floating particles of leaves.

The apparatus is also made in portable forms, which, mounted on one or more vehicles, self-propelling or horse-drawn, can go from farm to farm, and even operate in the field, saving the cost of transporting the heavy, undried leaves.

Beet leaves dried by this process are equal in food value to good meadow hay. They keep indefinitely,

Fig. 10.—UPPER PART OF BUETTNER BEET DRYER, SHOWING FURNACE AND CENTRIFUGAL SEPARATOR.

possess an agreeable odor and are greedily eaten by cattle. The cost of drying is small and the dried leaves never produce the disorders that are often caused by feeding beet leaves fresh or in the form of ensilage.

On the farm, the usefulness of the universal drying apparatus is not limited to the beet harvest, but may be extended over a great part of the year and to many crops. It may be employed to advantage in curing fodder corn, lupine, vetches, and even clover and grass, in wet seasons and on wet land, or municipal sewage farms, for example. Mixed vetches, peas, and beans, sown after winter barley and cured by this process, furnish a fodder for work horses that is little inferior to oats. Thus the same land can be made to furnish two full crops of fodder in a year, but the second crop could not be cured without artificial drying.

Chicory leaves, which in the fresh state are too bitter to be eaten readily by animals and are usually plowed under, may be converted by artificial drying into palatable and nutritious fodder. Very good fodder can even be made in this way of potato tops. It has been estimated that $120,000,000 could be saved annually by drying all the beet leaves and potato tops produced in Germany.

Dried beets, of course, are very nutritious and in

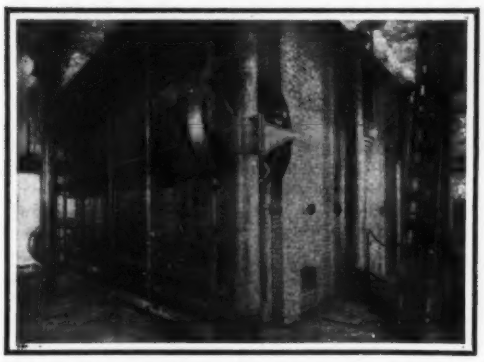


Fig. 11.—LOWER PART OF BUETTNER BEET DRYER.

seasons of abundance it is advisable to dry the excess rather than to put it into silos. The beets must be sliced or cut into small pieces before they are put into the drier. Even beets that have been apparently made worthless by freezing form a nutritious fodder after drying. In the curing of chicory root, which is commonly performed in primitive kilns with great waste of fuel, a great saving is effected by the employment of modern apparatus, such as the Buettner universal dryer.

Artificial drying is of very great value in grain culture, in which the quality of the crop depends largely on weather conditions during harvest. Grain harvested in wet weather soon acquires a musty odor that seriously affects its market value. Furthermore, the loss of weight during storage increases rapidly with the dampness of the grain. The loss through dampness, in Germany, has been estimated as $15,000,000 in 1899 (a comparatively dry year) and more than $60,000,000 in 1897. To these direct and known

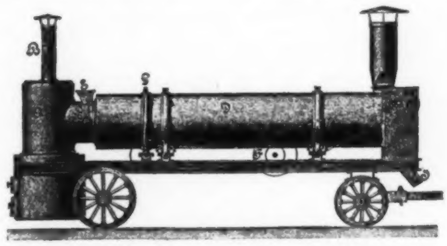


Fig. 12.—PORTABLE UNIVERSAL DRYER, SMALL MODEL.

losses must be added the incalculable injury inflicted on the nation by the use of damaged grain as food. Now, all of these losses, direct and indirect, can be entirely avoided by the artificial drying of wet grain, and it may be predicted that within a few years many millions will be saved by the application of artificial drying to this field.

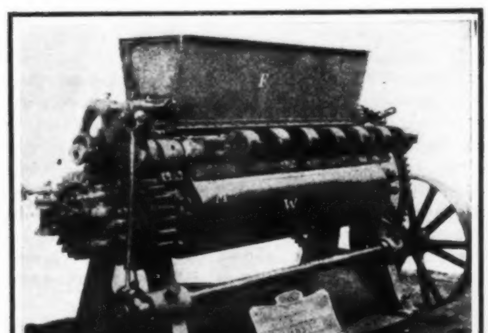
At present only a beginning has been made, but it is a brilliant one. Not only have large quantities of naturally wet grain been dried out with perfect success in the universal drier, but many cargoes of grain damaged in transit and containing up to 40 per cent of water, which would have been absolutely worthless without artificial drying, have been made available for various uses. This is a result of exceedingly great importance to the grain trade. The temperature of the gases can be so regulated that neither the bread making quality nor the germinating power of the grain is impaired. By the addition of a cooling cylinder, through which the grain passes after leaving the drying cylinder, the grain is delivered in a condition in which it can be stored with safety. The same process is obviously applicable to seeds of all kinds.

Germany produces annually 43 million tons of potatoes. Of this vast quantity 10½ per cent, or 4½ million tons, are lost by shrinkage, sprouting, decay, etc. Nearly all of this loss could be avoided by artificial drying, which would also greatly diminish the cost of storage and transportation and produce other eco-

Fig. 13.—PORTABLE UNIVERSAL DRYER, LARGE MODEL.

nomic advantages. Dried potatoes need only be soaked in water to furnish wholesome food of uniform quality, while undried potatoes must be cooked, are subject to decay and for this reason often cause disease. Experiments in feeding cattle and swine with dried potatoes have been very successful, and they may advantageously replace a large part of the grain ration of horses. The addition of more concentrated food is not necessary with dried, as it is with fresh potatoes. As dried potatoes can be kept for years, artificial drying on a large scale would equalize prices in good and bad seasons and throughout the world.

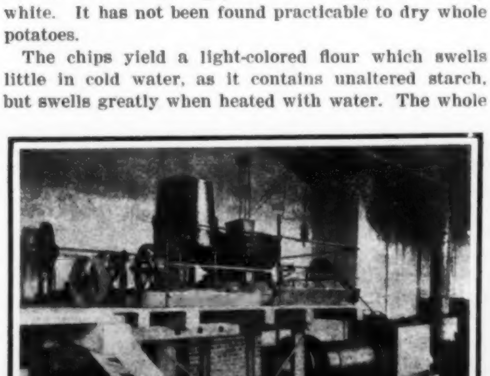
Dried potatoes are perfectly well adapted for the manufacture of alcohol and compressed yeast, and they have been used with good results as human food in the army and navy and elsewhere. In the form of meal they are already used largely by bakers for mixing with German wheat flour, which does not bake well when used alone and had formerly been mixed with imported flour. Already potatoes are artificially dried in larger quantities than any other German agricultural product, except beets.



BUETTNER ROLLER DRYER.

There are two distinct types of apparatus for drying potatoes, one employing hot air and combustion gases applied directly as in the apparatus described above, the other operated by steam. The products of the two processes differ greatly in appearance but are equal in digestibility, keeping qualities, and market value. In the first process the potatoes are cut into chips or slices about ¼ inch thick, in the second they are steamed and rolled into flakes before drying. The dried flakes are very thin and fragile, pale yellow, and resemble wood shavings; the dried chips are nearly white. It has not been found practicable to dry whole potatoes.

The chips yield a light-colored flour which swells little in cold water, as it contains unaltered starch, but swells greatly when heated with water. The whole



VIEW OF UNIVERSAL DRYER AS USED FOR DRYING POTATOES.

dried chips swell even in cold water and assume nearly the size and form which they had before drying. The dried flakes and the flour made from them swell rapidly in cold water, as their starch has been altered by the preliminary steaming. This difference in the character of the starch has no appreciable effect on the digestibility, though in general the chips are best adapted to large and adult animals and the flakes to small, young, and sickly ones.

The Buettner universal drier requires only a change in the cutter and the addition of washing and cleaning machines to adapt it to the drying of potatoes in chips or slices. Figs. 4, 5, and 6 show the plan and longitudinal and transverse vertical sections of a large potato drying plant of this character. The potatoes pass along the channel (*b*) to the washing machine (*r*) and the stone and grit separator (*c*). They are then carried by the screw (*l*) and the inclined conveyor (*f*) to the cutter (*t*) over the drying cylinder (*h*). The fresh chips reach the cylinder by means of the conveyor (*g*) and the dried chips emerge from the other end, at (*k*).

The dried potato flakes are produced by the Buettner roller drier (Figs. 7, 8, and 9). From the washing machine (*A*) the potatoes go, by means of the conveyor (*B*) and shaft (*C*) to the storeroom (*D*). The cleaned potatoes are fed, from time to time, into the steamer (*E*), where they are steamed for ½ or ¾ hour and then discharged into the hopper (*F*), where a revolving stirrer breaks them up and feeds them to the rollers (*W*), which are filled with steam at a pressure of 5 or 6 atmospheres. Here the potatoes are rolled into a thin sheet which, adhering to the hot rollers, is quickly dried and is finally removed by the scrapers (*M*) after remaining in contact with the rollers during three-quarters of a revolution. The irregular fragments thus produced fall into hoppers which contain mechanism that reduces them to uniform flakes, ventilates and cools them, and delivers them to the conveyor (*H*), by which and other conveyors they are carried either to a storeroom or to a mill where they are converted into flour.

This apparatus is well adapted to the desiccation of other substances, especially those of liquid or pasty form, such as milk, yeast, crushed fruit, blood, and the waste products of distilleries and starch factories.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

THE BIOLOGY OF CHLOROPHYL.

CHLOROPHYL AND THE RELATION OF GREEN PLANTS TO LIGHT.

BY GUENTHER SCHMID.

THERE is no need to emphasize the importance of the rôle played by the green constituent of the leaves of plants, the so-called chlorophyl. All the processes involved in the assimilation of carbon are, it appears, inevitably bound up with action of chlorophyl. It has long been known, on experimental evidence, that portions of the plant which are not colored green by chlorophyl are incapable of assisting in the assimilation process. As to the mode of action of this green substance, however, decisive experimental data are still wanting. Possibly chlorophyl fulfills only a secondary function in the synthesis of the organic compounds in the plant, by conveying to the plasma the light energy absorbed in the green organs. For a proper understanding of the subject, it is necessary to call to mind some facts regarding localization of chlorophyl in the plant. It is attached to certain small protoplasm corpuscles (at any rate in vascular plants), the so-called chromatophores which are scattered through the protoplasm of the cells in the green parts of the plant. These chromatophores have the typical granular or frothy appearance of protoplasm in general, but are distinguished by the presence of very fine granules of fat impregnated with a green coloring body, chlorophyl. By means of suitable solvents, such as alcohol, the chlorophyl can be extracted from the plant. It has been shown to be made up of two constituents, one, so-called cyanophyl, of bluish-green color, the other, xanthophyl, yellow. These, mixed in varying proportions in different plants, give rise to the different shades of foliage.

The question has been raised whether chlorophyl is an indispensable agent for carbon assimilation in all plants. Fungi and bacteria, in so far as they may be reckoned among plants, do not enter into consideration, since they take up ready-formed organic matter into their systems. As for brown and red algæ, they too possess chlorophyl, which, however, is masked by other pigments. It seems now very probable that in such cases the chlorophyl does not alone fulfill the function of absorbing light, but shares it with the other pigments. Hans Molisch has endeavored to show that in brown algæ, diatoms, and the orchid *Noettia nidus avis* (bird's nest orchid) we have, not a case of masking of the chlorophyl, but an actual absence of this body, whose place is taken by a brown pigment, so-called phaeophyl. This latter readily passes into chlorophyl by a chemical transformation.

The fact that the chromatophores have a coloration other than green in brown and red algæ and the cyanophyceæ (bluish-green algæ) naturally throws considerable doubt on the supposition that the green pigment is indispensable for plant life. In this connection the observations of Th. W. Engelmann are of interest. Some sixteen years ago this physiologist carried out an investigation on the relation between light absorption and assimilation, and summarized his results in the law: "The light which is mainly active in assimilation is that complementary to the color of the plant." He furthermore showed that in the case of the Rhodophyceæ green light is the principal agent. These red algæ grow in the sea at greater depths than any other non-parasitic plant. Says Engelmann:

"Even within but a short distance from the surface the green and greenish-blue rays have a much greater relative (though smaller absolute) intensity than they had in the original incident light, while the red and yellow rays are correspondingly much reduced in intensity. Since these last and the red rays are the most active in furthering assimilation in green cells, and the green rays are least effective, green plants must be at a disadvantage, even at relatively small depths, as compared with red cells, in which the green rays are the most energetic in furthering assimilation."

Along another line the investigation was pushed by N. Gaidukow, who attacked the problem, whether it was possible to convert one kind of alga into another, on the basis of Engelmann's law. He exposed a number of different cyanophyceæ to rays from separate portions of the spectrum, and succeeded in thus causing these algæ to assume a reddish color under green illumination, a brownish color under the influence of blue light, and a green color in red light. In other words, the plants adapted their color to the light under which they were placed, and assumed a complementary hue.

From the study of the assimilating action of chlorophyl in low plant forms, it was natural to pass to the investigation of higher types on land and in shallow water. This matter is treated by Ernst Stahl of Jena in his recent work, "The Biology of Chlorophyl." The question at issue is this: What is the reason for the green color of the plant organs in which carbon dioxide is decomposed under the action of light? Such a question has hitherto been regarded as not worth discussing. The green color of chlorophyl was accepted as a fact.

Supposing that there were some relation between the green color of leaves and illumination, then the first step to take was to determine what constituents were predominant in sunlight after reflection and partial absorption by the atmosphere. Stahl points out that in the course of the day the sky shows principally blue and red. A pronounced green color never occurs. According to the researches of Lord Rayleigh and Abney, daylight after passage through the atmosphere consists of diffused and direct sunlight. In the diffused (i. e., irregularly reflected) light blue and violet rays predominate very largely—as in the blue light from the sky—while in direct sunlight red and yellow rays are the chief constituents. Plants are therefore exposed principally to blue, red, and yellow rays. It may appear at first sight that Engelmann's theory did not apply in this case. In point of fact, however, chlorophyl does absorb only these particular rays, and transmits the green practically untouched. If sunlight which has passed through chlorophyl is examined with a spectroscope, practically only the green is visible, and there is more or less complete extinction in the red, yellow, blue, and violet. Incidentally it is a remarkable fact that the extreme visible red and ultra-red are not absorbed, but pass through without being utilized. Now Engelmann has shown that it is just in the red and blue that the maximum assimilating effect occurs.

Now it might be asked why foliage is not black, in which case it would be able to utilize the entire scope of the sun's radiation. For we can hardly suppose that the transmitted portion of the spectrum is quite incapable of assisting in the assimilation of carbon. We must conclude that there must be some cogent reason why the plants select the rays mentioned above to carry on the decomposition of carbon dioxide. Under different circumstances, as in the case of the red algæ, absorption of the green rays also might have been possible. In any case, black chlorophyl would be capable of utilizing even the most subdued light. We must, however, not leave out of account the thermal effects; it must be borne in mind that the organism can stand only a certain limited degree of heating, which, if surpassed, causes the death of the plant. This source of danger, as Stahl has shown, is more imminent than is commonly supposed. Even algæ, although completely immersed in water, may rapidly be killed by overheating if exposed to intense illumination. This danger of destruction by the thermal effect would be much greater if the principal heating constituent of light—the ultra-red rays—were also absorbed by the chlorophyl. It will therefore be seen how closely plants have adapted themselves to normal conditions, so as to protect the green organs from overheating, and at the same time to enable them to utilize to the fullest possible extent even very weak light. If chlorophyl were capable of absorbing green light also, this would only cause injury to the plant. For in subdued light there would be no appreciable gain, while in bright sunlight greater absorption would indeed take place, but also greater heating, which the plant is at such pains to avoid.

If it is a fact that overheating is a danger to which plants are constantly exposed, and that chlorophyl itself is adjusted to a certain normal illumination, then we must expect that the living organism, with its capacity for adaptation, will have developed some protective characters against this, as against any other harmful agencies. In this connection we call to mind J. Wiesner's observation of leaves turning their edge toward the direction of the maximum intensity of diffused light (Der Lichtgenuss der Pflanzen, Leipzig, 1907); further, certain other movements of plant organs which have been known for some time and whose purpose is a proper control of light and heat.

It has been shown that water plants, and those growing in shady places, assume a lighter color if exposed to bright sunlight. In fact, this action is so pronounced that a photographic copy of an opaque object can be made on a leaf, just as on a sensitized paper or plate, the portions protected from the sun retaining their dark color. Stahl has investigated the processes involved, and has found that the effect is due to a rearrangement of the chlorophyl corpuscles. In complete darkness, as at night, the chromatophores are distributed irregularly on all the cell walls. In diffused light the chromatophore plates turn their flat side to the light, so as to get the full benefit of the light. In direct sunlight, however, the plates assume the "profile" position, turning their edge to the light.

These experiments can be readily carried out for example with leaves of the elder tree. Hitherto this rearrangement of the chlorophyl bodies was regarded as a protection against a destructive action of light upon the chlorophyl. Stahl thinks that it is rather a safeguard against overheating. Another phenomenon which, according to Stahl, depends on the relation of plants to absorption and reflection of heat is the gradation of tints at different seasons and in different species. Thus plants growing in dry, sunny places have chlorophyl of a light color. For then it is essential to absorb as little heat as possible under the conditions to which they are adapted, and to give up only a minimum of moisture. On the other hand, plants growing in deep, moist humus, such as boxwood, ivy, evergreen, are colored deep green. The researches on these interesting problems are far from being concluded, but will require further extension and modification.

We have so far, in our discussion, paid little attention to the chemical composition of chlorophyl. As a matter of fact, until recently there was practically no positive knowledge regarding the nature of this coloring matter. Even at the present day the question cannot be regarded as finally settled. It is true that the chemists Willstätter and Mieg have made valuable contributions to our knowledge by their investigations. They determined that the crude chlorophyl is not one individual substance, but is composed of a number of different pigments, among which are chloro-

phyl proper, carrotin, and xanthophyl, or rather the xanthophyls. Carrotin is the pigment found in the carrot and in red leaves. To this the hydrocarbon formula $C_{26}H_{38}$ was given by Arnaud in 1886. Now Willstätter and Mieg regard xanthophyl as an oxide of carrotin, with the formula $C_{40}H_{56}O$. The crystallizable green constituent of chlorophyl is most nearly represented by the formula $C_{55}H_{72}O_{7}N_{4}Mg$. In addition to this there is an amorphous green substance, which could not be analyzed quantitatively. Qualitative tests, however, showed that it also contained no trace of iron. This fact is very remarkable, as iron is indispensable for the development of the green color in plants; in its absence a morbid condition arises, so-called etiolation, in which the plant blanches.

On the basis of these chemical facts Stahl attacked the problem of the biological interpretation of certain processes in the life of a plant; the disappearance of the chlorophyl before the autumn shedding of leaves, and in the condition of etiolation. In a series of new experiments he established the fact, in confirmation of previous results, that the green constituent of chlorophyl migrates in autumn through the leaf stalk, in altered form, into special organs which serve as storehouses. Only the xanthophyl remains in the leaf. From the chemistry of chlorophyl this simply means that the plant reabsorbs the valuable constituents containing nitrogen and magnesium, while it throws off the xanthophyls, which can at any time be readily regenerated from the atmosphere and water. A somewhat similar state of affairs occurs when a plant grows in the dark. It is a familiar observation that under these conditions the plant produces no leaves, but grows a greatly elongated stem. At the same time the chlorophyl disappears, leaving only the xanthophyl; the plant blanches or etiolates. We must not regard this etiolation so much as a disease, Stahl points out, but as a natural process of importance to a seed germinating under the soil. If it happens to be somewhat deeply buried, it must evidently strain all its powers to bring the organs of assimilation, the leaves, to the surface. At the same time the absence of chlorophyl under these conditions is readily intelligible, for in the absence of light that substance would be quite useless. Nevertheless, chlorophyl can be formed even in the dark, as is proved by cotyledons of certain gymnosperms, which have their normal green color also when grown in the dark. In etiolation the formation of chlorophyl is evidently arrested in favor of increased growth. This is another example of the tendency characteristic of all organisms, to employ the most economic means for the various processes incidental to life.

The biological point of view, as adopted by Stahl, suggests a number of new problems for research. It is such new problems which contribute most to the advancement of science in virgin fields. For this reason alone enough stress cannot be laid upon the study of the biology of living organisms, a branch of science which is still in its infancy. Its proper pursuit, however, requires not only a detailed study of organography and of general botany and zoology, but above all of physiology also, a science in which there still remains a wide field for further work, especially in its zoological branch.—Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from Prometheus.

COAL ANALYSIS.*

COAL BEDS AND THEIR COMPOSITION.

BY DR. H. FOSTER BAIN, DIRECTOR ILLINOIS STATE GEOLOGICAL SURVEY.

COAL-BEARING rocks underlie three-fourths of Illinois, including 85 of its 102 counties. The coal area is estimated at from 36,000 to 42,000 square miles—the largest area of bituminous coal within any single State. There are approximately 1,000 mines in the State of which over 400 are railway shipping mines. The work of the State Geological Survey is therefore very largely devoted to coal and the problems of the coal fields.

Illinois ranks second among the States in the production of coal. In 1907, 51,317,146 tons, having a total value of $54,687,382, were mined. The figures for 1908 are not complete but preliminary estimates indicate that Illinois was almost alone among the States in holding its production. While in the country as a whole the amount mined fell off from 15 to 20 per cent, Illinois mines produced as much as or possibly more than in 1907, a record year. Despite this gratifying fact it remains true that our mines are not working to anything like their capacity. In 1907 the average number of days worked was 218. It would probably be fair to assume 300 working days a year as possible. On this basis there was a loss of 30 per cent of the possible working time and this is not an unusual per cent of loss in the State. The reasons for this are complex. In part they lie in the nature of the coal which prevents its storage without spontaneous combustion; in part, in the general ignorance as to correct methods of firing and the real value of the coal; and finally in part, in the present organization of the industry with excessive competition in selling. The net results are bad for the industry and therefore for the State as a whole. Cheap coal reduces manufacturing costs but allows wasteful burning. It also entails wasteful mining and even prevents the introduction of methods of safeguarding the men in the mines. It is a serious question whether we are not paying, in loss of life in the mines, in loss of efficiency in our plants, and in loss of interest and capital invested in the industry, more than the cheapness of the coal is worth.

The study of the coal and coal fields of the State has been carried on both in the field and office. The work has been directed toward:

1. The solving of problems of stratigraphy such as the distribution and correlation of various coal beds, together with the collection of all data relating to the origin and the mode of deposition of the coal and accompanying beds.
2. Study of the composition and uses of coals.
3. A study of the mode of occurrence of coal as relates to the methods and costs of mining.
4. A study of the preparation of the coal for the market, its transportation, its normal markets, and the competitions which it meets.

The first step in the solution of the problems of stratigraphy is the making of accurate detailed maps and the compilation of drill records. This is now being done and considerable areas near Peoria, Springfield, Belleville, and in the Saline and Williamson County fields have been surveyed in co-operation with the United States Geological Survey. These maps show the thickness and lie of the coal beds and from them it will be possible to tell quite exactly how much coal is present and to plan its economical working. At present it is only possible to guess at the original content of the field and these guesses vary from 136 billion to 24 billion tons.

The study of the composition of the coal is directed especially toward the determination of its availability and the best means of using it. Samples are taken by uniform methods in the mine and in the market and in connection with the Engineering Experiment Station elaborate experiments are being made of the methods of storage, of handling the coal, and of burning it. We hope soon to take up the matter of gas production and coke making and have had under way for some time certain preliminary experiments.

The mode of occurrence as relates to mining methods and costs has been barely touched. In my judgment it would be well if the State made separate provision for this work. In the absence of special provision we are attempting to gather such notes as we can in the course of our regular work. It has been found impracticable at the present time, mainly owing to limitations of funds, to undertake certain highly desirable studies of the technology of the mining industry and of the geographical distribution of markets for Illinois coals. It is believed that much good would result from investigations along these lines and that certain portions of the work are well within the proper field of the State Geological Survey. It is now well known that there is, under present commercial conditions, an enormous waste in the mining of Illinois coal. In individual districts it has been estimated to amount to as much as 60 per cent, though, of course, such losses are not general. It would, however, probably be safe to say that in very many places 40 per cent of the coal in the ground is left unmined or is ruined in the process of mining. In addition, the methods of mining introduced in recent years have greatly increased the production of fine sizes and have also, seemingly, increased the danger to life and property in the mines. The causes for all these losses are complex, and it is not to be supposed that either operators or miners willingly submit to them. Neither is it to be expected that the losses of life and property can be entirely done away with. At the same time experience has abundantly proven that careful and impartial investigations of such conditions will point the way to the remedying of some at least of the abuses, and in view of the enormous importance of the subject to the State and the public at large, such studies are believed to be amply warranted.

There has been no opportunity as yet to seriously take up the study of markets. "The expansion of markets for Illinois coal is a matter of vital importance to the coal industry and indirectly to the people of the entire State. One of the most important means of promoting this expansion is by removing certain misapprehensions as to the quality of the coal and the pointing out of better means of burning, so as to increase its efficiency and decrease the smoke produced. This work has been taken up vigorously by the Engineering Experiment Station, which has published excellent bulletins on How to Burn Illinois Coal Without Smoke and other similar subjects. In addition to this valuable work, there should be investigations of the actual markets for the different grades of coal and of possible enlargements of these markets. There are large areas to the northwest within which Illinois washed coals might profitably supplant eastern coals now being sold. There are other areas to the south and west where, with proper organization of transportation agencies, even in advance of improvement of the rivers, trade territory could be gained. Any widening of the market would be of large benefit to the local industry, particularly if the summer market could be increased. For this reason the studies now under way relating to weathering of coal and coal storage are especially important."

* Delivered as an address before the Illinois Fuel Conference at the University of Illinois, Urbana, Ill.

THE JAVA SNAKE SKIN INDUSTRY.

A NEW industry has sprung up recently in the Dutch East Indies. In Batavia, the capital of Java, has been incorporated the Java Reptile Skin Company. The scope of this company is the furnishing of snake skins for the market. The company has several "factories" in the different islands, where snakes, dead or alive, can be exchanged by the natives for a small cash remuneration. Dead snakes are not worth much—about two to five cents; while live, healthy snakes, the larger the better, are worth all the way up to one dollar. The reason why dead snakes have such a low market value is that their skinning is difficult, the skins are lusterless and apt to be damaged during the process, while a live snake is easily skinned, and the skin has a particular sheen. The kind most sought for is a large snake, closely resembling the American python. This snake reaches sometimes a length of twenty feet and more. The process of skinning the snake is the following: The reptile is hung by the neck on a tree, while one man gets hold of the tail, trying to get the snake straight. Another, with a sharp knife, makes an incision around the part of the body that usually is called the neck, cuts down enough of the skin to get a good hold on it, and then, with a strong and steady pull, draws the skin backward over the body, as a glove is drawn from the hand. Of course, the reptile so treated rebels, but the man at the tail holds fast until the skin is pulled off entirely, by which time the unfortunate serpent is usually dead. The skin is then dried and prepared for the market.

THE two great enrichers of thermal chemistry were Berthelot and Thomsen. Berthelot died in the spring of 1907, at the age of eighty; Julius Thomsen has just left us, at the age of eighty-three. Thomsen devoted his life to the experimental advancement of thermal chemistry. His first memoir on this subject was published in 1853, his last a few years before his death. The permanent memorial of Thomsen's work is the four volumes of "Thermochemische Untersuchungen," published in the years 1882-86. Thomsen tells us that he formed the plan of the whole before he began his experiments, and that he adhered almost rigorously to that plan. When the work was nearly completed, he recognized that the science of thermal chemistry would be benefited by collecting and digesting his materials, and so he published his investigations and his theoretical discussions thereof in the four volumes which have established his fame. In 1905 Thomsen published a *résumé* of his principal experimental results and discussions in one volume. Unfortunately, that book was written in Danish; fortunately for English workers, an English translation of it has appeared in Longmans series of textbooks of physical chemistry, edited by Sir William Ramsay.

ENGINEERING NOTES.

Hitherto the deepest borehole in the world has been that near Rybnik, Upper Silesia, 2,003 meters. This depth has now been exceeded by a hole at Czuchow, in the same district, which has already reached 2,156 meters, and is to be continued to 2,250 meters, if possible. The hole was commenced in December, 1906, with a diameter of 16 inches.

A dredge operated by a gasoline engine has been used on drainage work in Minnesota. The engine is of 50 horse-power capacity, the shovel holds 1¾ cubic yards, and the boom is 40 feet long. The machine excavates to a depth of 20 feet, and to a top width of 32 feet. When cutting a ditch 5 feet deep with a 6-foot bottom and side slopes of 1½ to 1, 400 linear feet have been excavated in 11 hours, with a crew of three men, and a foreman and one team. The work performed averaged 2,000 cubic yards per 22-hour day for six successive days. The gasoline per day of 22 hours amounted to 75 gallons. A small dynamo furnishes current for night lighting.

At a recent meeting of the Montreal Board of Trade, Mr. J. S. Armstrong, a New Brunswick engineer, submitted a plan for a tunnel under the river St. Lawrence at Quebec. He claimed that this scheme would not cost more than the proposed Quebec Bridge, and that it would meet the objections raised to that bridge in Montreal on account of its possible obstruction to shipping. The top of the tunnel would be 40 feet below the surface at the lowest tides, and it would be wide enough for four lines of rails and for the ordinary road traffic. It would not be built out in the country, where the bridge works are, but at Quebec itself, connecting the city with the town of Point Levis on the south shore.

There were 338 fever deaths in Chicago in 1908, or a rate of 15.6 per 100,000, lower by 12 per cent than 1907, about 33 per cent lower than the average of the last ten years, and 91 per cent lower than the record-breaking figure of 1891, when the appalling rate of 173.8 per 100,000 was recorded. For the nine years since the opening of the drainage canal, the average rate per 100,000 was 21.1, as against 57.7 for the nine years before the canal was opened. According to the bulletin of the Chicago Department of Health for February 20, 1909, if the pre-channel typhoid rate had prevailed during the last nine years there would have been 10,035 deaths from typhoid fever in that period, or 6,014 more than actually occurred. Figuring on the basis of the legislative value of a human life, this saving represents the sum of $64,140,000 or more than the entire cost of the drainage channel to date.

The round house, which is a portion of the new work of the New York, New Haven & Hartford Railway at Waterbury, at present consists of ten stalls, each occupying about 8 deg. of the circle, and is connected at one end to a machine shop, into which locomotives from the round house tracks may be run *via* the central turntable. The house consists of four circumferential rows of hooped concrete columns, carrying beams and roof slabs of reinforced concrete. The smaller circumference, or the entrance, is closed in by large rolling doors between the columns and the outer rim by large glass windows directly in line with the tracks, filled in between with brick walls, so as to offer little obstruction to a possible uncontrollable locomotive. The columns and their connecting girders were cast in place, but the intermediate beams and the roof slabs were cast on the ground and afterward placed, locking the extending reinforcement and filling the joints with wet concrete.

ELECTRICAL NOTES.

In a series of researches upon the singing arc, M. La Rosa, an Italian scientist, obtains an arc which appears to give a higher temperature than the ordinary arc, and by placing powdered carbon in such an arc the carbon seems to become partly melted, contrary to what M. Moissan and others advanced. He uses a singing arc which contains only a condenser in the circuit, suppressing the usual self-induction. Such an arc is found to have a greater energy than the usual arc, and he wished to prove that it also had a higher heat. He placed sugar charcoal in fine powder between the carbons of the arc, and obtains a crust which is formed by the action of the heat. Microscopic examination shows that some of the particles are transformed to graphite and their appearance is different from the ordinary carbon particles. As the result of these researches he is led to consider that the particles of carbon which are affected by the arc discharge reached the liquid state.

Electric bread-baking processes are coming into use abroad. One of these is working in Switzerland at Kerns, where a firm is now delivering bread baked in the electric oven. This latter is of an improved type and has the latest devices which are needed to secure a good result. It is about 8 feet long and 4 feet wide and has a baking surface of 3 square yards. Such a furnace will give 100 pounds of bread in one baking, in 2 and 3-pound loaves. The furnace carries a set of 42 heating tubes in which the current passes, and the tubes are built along the base and the vaulting. Means are provided so as to distribute the heat in the different tubes according to their position in the furnace, owing to the unequal cooling. Thus the current is gradually lessened toward the back of the furnace. The furnace comes up to the baking heat within two hours, and in twelve hours it will furnish eight batches of 100 pounds, or 800 pounds, at a cost of 1.6 cent per pound for the heating.

Not infrequently the medical journals revert to the danger of infection from talking into a public telephone. To overcome this apprehension a number of antiseptic mouthpieces have been fitted to transmitters. These usually contain some disinfectant that at the same time gives a pleasant odor to the mouthpiece. Where these are not provided a simple remedy has been suggested by Mr. Rosser S. Dean, who, writing in an English paper, says: "There has been some talk about danger of infection from the use of public telephones. May I suggest a simple contrivance by way of safeguard for those who care to use any? Fit a piece of thin but tough paper (good typewriting paper does well) over the mouthpiece of the transmitter, so as to form a little tight drumhead to it. If the paper be strong enough it will suffice to crumple it tightly round the neck of the cup, but a small elastic band holds better. The paper is fitted in a few seconds and removed as quickly. The user speaks against it, but without touching it. I do not find that the transmission of the voice is interfered with in the least. The idea is not mine, for I saw something of the kind on a neighbor's telephone and promptly adopted the idea for home use, but I think it will be new to most people, and may be welcome to some." By actual trial on a fairly good telephone line it will be found that this paper scheme does not appreciably detract from the clearness of the voice, if the paper is put on tightly and is not too thick or too thin. A little pad of the paper can be readily carried by anyone willing to go to a slight inconvenience to allay nervousness in the use of a great public utility. While the bulk of the public enjoys the use of the telephone without trepidation, those who are scrupulous in this respect will probably find comfort in adopting the paper protector.—Western Electrician.

TRADE NOTES AND FORMULÆ.

Pegamoid.—For the preparation of a coating for bookbinders' boards, the following receipt displays great similarity with the composition of pegamoid: 100 parts each of camphor, mastic, and acetic ether, 50 parts each of bleached shellac and ethyl ether, and 200 parts each of guncotton and acetone. In the pegamoid, however, castor oil is said to also be an ingredient.

Bordeaux mixture as a preventive of leaf diseases is usually a solution of blue copperas and lime. It is most practical to dissolve in 50 parts of water, 2 parts of copper (blue) vitriol, and also in 50 parts of water, 1½ parts of soda. While stirring, the soda solution is added to the copper vitriol solution. This solution can also be used for killing off the lichens on fruit trees.

Parliament Ink.—175 parts Aleppo gall nuts are crushed very fine and boiled with 11.250 parts of water for a quarter of an hour, strained, and the residue again boiled for half an hour in 7,800 parts of water. The cleared decoctions are mixed, add 510 parts of gum Arabic, previously dissolved in water, then 180 parts of glycerine, and finally 625 parts of sulphate of iron, and 225 parts of sulphate of copper, previously dissolved. The finished ink is strained through linen.

Styresin is the name of a sealing material for microscopic preparations. Solid starch is dissolved in about five times its weight of coal tar benzol and then petroleum benzine is slowly added, stirring meanwhile. The rosin is then precipitated first as a blackish-brown mass. The addition of petroleum benzine is stopped as soon as the fluid has acquired a Rhine wine color, allowed to stand, filtered, and the solvent distilled off. A substance remains which is faultless as a sealing material.

Silk powder, for imparting to fabrics or paper hangings an attractive silky luster. We first subject refuse silk, or whole cocoons, to a soap bath, with oil, which separates the different fibers; the silk is then weighted with sugar and stannic salt, which makes it brittle and easy to pulverize. The powder is again weighted with soda, water glass, and sugar, colored and made bright in a moss or sea-weed decoction. Finally, in a sort of disintegrator, through which a heated current of air passes, it is transformed into a fine powder and dried.

Peuto Epilatoire is the name of a highly commended depilatory for tanneries, which, according to Eitner, is a 36 per cent solution of a bisulphite of arsenic and sodium, and except in its greater cost and poisonous character, does not differ in effect from the alkaline sulphides and their combinations hitherto employed. As found in the market, it is a yellowish caustic fluid of 1.112 specific gravity, which can easily be produced by slaking 5 parts of lime, adding 10 parts of soda, 15 parts of hot water, and 2 parts of orpiment. After settling, the preparation is ready for use.

Alcohol briquettes are small tin boxes, filled with a yellowish combustible mass, that can be used like a spirit lamp. The flame is simply extinguished by replacing the lid; the contents can thus be preserved for any length of time, until exhausted. The dough-like substance that forms the filling of the boxes, is easily prepared and is made as follows: In a vessel of sufficient size, 1,000 parts of alcohol are heated in the water bath. As a rule, denatured alcohol is used. When the fluid has a temperature of 140 deg. F., 30 parts of grated and dried Venetian soap and 2 parts of gum lac are added. The fluid is then stirred until the substances added are completely dissolved and the mixture is then poured into the boxes, which are at once closed. On cooling the mixture solidifies.

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